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TABLE OF LEADING ARTICLES.

Street Lighting in St. Louis........ 765
Quicksand 766
Combining Power Plants Serving Similar Territory.. 766
The Salt River Project (Illustrated)........ 768
Sanitary Patrol of Watersheds........ 769
The Hydro-Electric Power Plant of the Winchester & Washington City Railway Company (Illustrated.) 771
The Port Works at Havre, France........ 773
A Reservoir Slope Protection of Reinforced Concrete 774
Engineering Personality and Organization........ 774
The Design of Retaining Walls—II. (Illustrated).... 777
Waterways of New Jersey. (Illustrated)........ 778
The First Case Under the Pennsylvania River Pollution Law........ 781
A 12,000-Barrel Cement Mill in California. (Illustrated) 782
The Fort Garry Station and Local Freight Terminal, Winnipeg, Manitoba. (Illustrated)........ 787
The Concrete Mixer Cars of the Chicago Railways Company. (Illustrated) 790
The Proposed River Training Wall at Rangoon, India. (Illustrated) 790
Transportation of Ashes and Rubbish in Philadelphia. 791
The Proposed Auxiliary Fire-Protection System for San Francisco........ 791
Estimate Curves for Manholes. (Illustrated)........ 792
Fast Railway Location........ 792
The Cost of the Cold Springs Dam........ 792

Street Lighting in St. Louis.

The present contract for street lighting in St. Louis expires on Aug. 31, 1910. The conditions in the city on the termination of previous contracts for such service were so unfortunate that the St. Louis Civic League resolved more than a year ago to collect information on the subject of street lighting and present it to the taxpayers, in order that, if possible, the city authorities might be persuaded to make new lighting contracts before the expiration of those now in force. The last time anything of this nature occurred was in January, 1900, when the streets were lighted by arc lights and the alleys by incandescent electric lights. When these contracts expired no new arrangements had been made for public lighting, and the greater part of the city was in darkness for a month. Some of the public hospitals and asylums would have been without light, other than candles and oil lamps, had not their superintendents or a few public-spirited citizens paid the bills. Daily mass-meetings of taxpayers were held, but it was not until Jan. 16 that temporary lighting bills were passed and not until Feb. 2 that contracts were signed for lighting the city. These contracts ran until Sept. 1 of that year, and others were then signed for a ten-year period. Experience like this was not a new thing in the city, moreover, and it is therefore evident that the Civic League has fulfilled a meritorious public service in beginning the discussion of street lighting at this time.

More than a year ago the League appointed a committee to investigate and report on the most desirable and economical method of lighting the streets and alleys. The chairman of the committee was Prof. J. L. Van Ornum, head of the civil engineering department of Washington University, and the other members were Mr. E. L. Adreon, vice-president and general manager of the American Brake Co., who for eight years served as comptroller of St. Louis; Mr. Joseph D. Bascom, of the Broderick & Bascom Rope Co.; Mr. Trescott F. Chaplin, a St. Louis attorney; Mr. John J. Lichter, a consulting mechanical engineer of St. Louis, and Prof. A. S. Langsdorf, head of the electrical engineering department of Washington University. It is evident that this committee was an unusually competent one to pass judgment on the engineering, financial and legal problems of the subject. It carried on its investigations for more than a year and it has recently submitted a report which the Civic League has endorsed with its hearty approval. It is a particularly interesting document because, unlike most such reports from civic associations, this does not recommend municipal ownership or competition as a means of securing low lighting rates, but advises granting exclusive franchises with public control of rates. This conclusion is based upon the local conditions in St. Louis and on the present state of the art of public lighting, and has been reached by a logical process entirely different from the esoteric reasoning that makes municipal ownership a panacea for all civic ills and from the downright denial of matters of common knowledge regarding overcapitalization that marks many arguments for universal private control of public-service utilities. The committee points out that what may be useful in a small city may be extremely bad policy in a large city, and measures that may be for the public welfare of communities in one part of the country may be injurious in another section. It recognizes that if the public gives a franchise for street lighting to a company, the stockholders of that company deserve to receive protection for their capital and a fair return upon it, while it is also in accord with the rapidly-growing belief that companies operating under public franchises must submit to a regulation of their rates in return for their franchises.

The committee bases its arguments largely on the assertion that street lighting is a municipal function of a distinctly public character. The use of the streets for wires, poles and conduits must be permitted, the style of the lamp-posts should be made uniform, and the kind and amount of public lighting must be what the taxpayers desire. Consequently the work must either be done by the city itself, or subject to its control. It should not be subject to competition, the committee points out, because such competition means a duplication of costly equipment, with corresponding duplication of maintenance and operating charges. The readers of this journal will recall that formerly competition was considered the leading means of securing low rates, but in those cities where it was tried a consolidation of the competing companies has taken place, with the result that prices of lighting have risen considerably or else there has been a great loss to investors in the shares of one or more of the competing companies. Street lighting is thus essentially a natural monopoly, and the problem is to determine the extent of the public control over it that best satisfies local conditions.

The committee has reached the conclusion that there is no political advantage in municipal ownership, a conclusion that is distinctly novel for a civic association committee to reach, but nevertheless one that accords with the trend of opinion as our definite knowledge relating to the operation of public-utilities increases. With the municipal operation of a public service like lighting, there is danger of the development of a body of employees paid more than the prevailing rate of wages and used as a political organization. There is the further danger, which has been shown by experience to be a real one and not a theory, that the city council may refuse to appropriate money for necessary repairs and improvements to a plant, in order that it may deteriorate to such an extent that the citizens will agree to leasing it to private parties. With a public-service corporation engaged in municipal lighting there is the danger of bribery of public officials to secure favors of one sort or another. It is manifest, therefore, that there is danger in either course, and that the only remedy for bad conditions in either case is precisely the same, the election of men to all civic positions who will be faithful to their trust and competent to discharge their duties.

The committee of the Civic League has carefully examined the statistics of the municipal electric lighting works of Chicago and Detroit and finds that the cost of lighting from those plants is higher than that for which a similar service could be obtained from the companies engaged in selling current in those two cities. The committee's figures differ from those of the municipal authorities in charge of the two plants, but the reasons for the differences, which this journal believes to be valid, are stated at length. These two cities are the only large municipalities in the country which have undertaken the direct management of public lighting, and their experience does not warrant St. Louis to conclude that a municipal plant will furnish lighting more economically than a large corporation under the control of a just and intelligent public utilities commission. Great progress is now being made in the art of illumination, a fact acknowledged by the manager of one of the lighting companies of St. Louis, who says that the company can furnish lights equivalent to those now in use at a considerably lower price than the ruling one at present. In view of this fact, the Civic League has reached the conclusion that the city will be best served so far as light is concerned by taking advantage of a statute providing for the appointment of a commission to examine the condition of any corporation engaged in furnishing gas, steam or electricity, to determine what is a reasonable rate. After the commission has found out the actual cost of supplying current, the city can then fix the rates, subject to the restriction that they must be reasonable and must not be changed more often than once every two years. Various technical details of lighting are also discussed by the committee of the Civic League, but these are of minor interest compared with its recommendations on the general subject of street lighting. The arguments are so sane, so free from the cant and bluster that characterize many of the arguments for and against municipal ownership, that the report deserves more than casual consideration.

Quicksand.

On the whole, it is not particularly difficult to describe most materials with which the engineer has to deal in the generality of engineering problems, but judging from the literature of foundation and other construction, quicksand is a remarkable exception to the preceding observation. In spite of the fact that there are a great number of grades of steel, when an engineer uses that term there is little or no doubt regarding the character of the material about which he writes or speaks. His context makes the use of his language clear and specific. There is rarely any doubt whether he means low, medium or high steel or whether he means rolled steel or steel castings. Similarly, if he has to deal with timber or masonry in their many grades, there is never any substantial difficulty in ascertaining precisely what he means by the language he employs. His references to the material which he has in mind for any particular purpose are plain and direct and there is no obscurity as to their meaning.

It is certainly singular that a material which has for so many years given to the engineer some of the most serious foundation or substructure difficulties which he has ever encountered and which has been so much discussed should have such an obscure character as scarcely ever to be defined alike by experienced engineers, and yet it is little exaggeration to state that quicksand is precisely such a material. No engineer who has ever had even a moderate amount of experience in foundation or other similar construction in soft material has escaped problems in actual field work which he would not hesitate to ascribe to the presence of "quicksand." If two or three engineers who have had such experiences should be asked in turn to define the material which had given them so much trouble, there is exceedingly little probability that any two of the answers would completely agree. If the "Transactions" of the Society of Civil Engineers be scrutinized there will be found a goodly number of definitions of quicksand, but it is doubtful whether any two out of the lot may be considered in substantial agreement.

In a recent important court case conducted by the Department of Justice, at Washington, one of the counsel engaged upon it had occasion to search with unusual care for a definition of this troublesome material. After finding and reading many descriptions of it, as given by practising engineers, he was completely dismayed by the apparent confusion with which these definitions seem to be hopelessly surrounded. One engineer described it as exceedingly fine but clear sand, saturated or super-saturated with water. Another gave an equally confident description of it as a mixture of fine sand and clay, also saturated with water, but without giving any proportions of the mixture. In another description it was insisted that the sand should be both fine and micaceous, whether clear or mixed with clayey material, and that the water of saturation should be in motion in order that the material should be really quick. As a matter of fact, none of these definitions or others of a similar character were wrong, and for that very reason, perhaps, the attorney was the more confused.

Material like quicksand, which possesses the property of being "quick" or mobile when saturated or super-saturated with water, may have almost any composition, provided it will flow in water under suitable conditions. If the quickest quicksand is so confined that it cannot flow in any direction it will sustain almost any load ordinarily used in earth foundations with complete stability; indeed, under such circumstances, it is really not quicksand, for it cannot flow or be "quick." If, however, supporting pressure be removed in one direction only, the material immediately flows and is in a condition to become exceedingly troublesome in substructure or similar work.

The fact that this material remains firmly and solidly in place as long as supporting pressure in all directions is supplied explains why penetrations in it by means not requiring the use of water may be reported as disclosing firm, stable material, although it at once becomes quick and mobile when that supporting pressure is removed.

The same attorney to whom reference is made above was much puzzled by a profile of borings, which, while it indicated fine micaceous sand, mud and soft blue clay, was supplemented by explanatory notes to the effect that these materials were all comparatively firm and stable while confined in place. When the excavation was in progress, however, and the materials became saturated with water, they were destructively quick and mobile and completely wrecked the sheet piling of the excavated enclosure.

All these apparently contradictory characteristics of so-called quicksand are in reality entirely harmonious, although engineers seldom refer to them as if they were. Any saturated material, such as clear, fine sand or a mixture of fine sand, especially if it is micaceous, with clay or clayey material, in a practically semi-liquid condition will flow almost like water and constitutes the most difficult of all materials to be held by sheet piling, even though it be firm and solid before being disturbed. Many a sheet-piled enclosure has been wrecked by the inward collapse of the sheet piling under pressure of this mobile material when being opposed by insufficient though apparently strong bracing. It has frequently flowed under the toe of heavy sheeting and found its way through appertures too narrow to be considered sources of any danger, running almost like water and even filling excavation enclosures. In fact, quicksand must be considered a broad and comprehensive term comprising a wide range of composite material, in many cases the only requisite quality being a capacity to flow dangerously when saturated or super-saturated with water.

Combining Power Plants Serving Similar Territory.

In the replacement of steam equipment by electricity in large industrial plants a feature that is often conspicuous is the consolidation of power plant apparatus at a central point and the elimination of scattered engine and boiler units formerly operated at poor efficiency, considering the needs of the whole works. Sometimes over a dozen engines located in different places have been thrown out of work by the new central plant, with its compactness, ability to produce power at the most modern figures, and capability of distributing with minimum average loss of energy. Two or three years ago a large engineering firm made an exhaustive study of the power conditions in the United States Navy Yards and, in harmony with the broad principles of economic consolidation, recommended the combining of power plants then serving different departments separately, to the end that many thousands of dollars might be saved yearly. Sooner or later this recommendation must be carried to its logical conclusion, and considering the limited distances over which power is ordinarily distributed in such yards, it was practically a foregone conclusion that consolidation would be recommended. In the field of long-distance power transmission, notably in connection with hydro-electric plants serving wide areas, sometimes a large section of a single State, it has been found advantageous from the dual standpoint of investment and operating economy to join even far-distant plants in one consolidated group of generating outfits.

Thus far this process of consolidation has not been carried to its full possibilities, particularly in some of the larger cities. The central station is of course trying to bring about the elimination of the isolated plant, which is one aspect of the consolidation problem, dependent upon specific conditions for proper solution. The problem here, however, is complicated by the factors of distribution loss and the need of selling power at a reasonable profit upon a large investment. The simpler case is afforded by the plant which is equipped with more or less antiquated machinery, producing power at relatively low efficiency and located in the neighborhood of one or more good-size stations producing current with first-class economy. There is often a chance in such instances for a mutual agreement whereby the better economy of the more modern plant can be placed at the service of the older installation, saving a desirable sum in any fixed period to the company which is handicapped by inferior apparatus.

In one case of this sort which appears to offer an excellent opportunity for combination work in power production, the two plants in mind are located within probably 1,500 ft. of one another, being on the opposite banks of a river which affords a good supply of condensing water. The cost of coal is $4 per ton at one station, and $4.10 at the other. One serves a large suburban city with electricity for all purposes except electric railway work, and the other serves a separate suburban district controlled by another company, the two plants, of course, being under different managements. The older station is equipped with three different makes of engines and two styles of generators, with belt driving, and is in general a plant that would have been considered modern back in the middle 90's. The other station is a first-class direct-connected plant with one make of engine and generating units, kept in proper condition for economical production. The rated capacity of the older plant is about 2,150 kw., while the newer station totals 4,700 kw. in generating apparatus. The cost of power per kilowatt-hour last year in the old station was 1.27 cents, compared with 1.05 cents in the other plant, or a difference of 21 per cent. against the old outfit as compared with the more modern installation. The output of the older plant was 2,785,000 units, and that of the newer station 5,953,000 units, making a difference in cost of about $6,827 per year in favor of the new station, supposing the two loads should be combined on the more modern plant, and not figuring the decreased labor cost resulting in the old station or the improved load factor of the newer plant.

It is probable that if the company owning the older plant desired to maintain it as a substation or distributing station of the newer one, the total annual saving in cost of operation would pay the charges on a substantial investment in improved distributing switchboard apparatus. In this case the question to be settled would be the willingness of the old company to make terms with the new station and the willingness of the latter to make a price to the former that would pay to discontinue the old plant. Aside from the negotiation phase of the question, it is clear that the newer station can produce cheaper power than the older one, and as the two are not competitive, it would certainly be an advantage to investigate the question of physically joining forces, whether or not the old company maintained a separate operating organization. Duplication of effort in such a field "goes against the grain" of an engineer whose desire is to see all natural resources husbanded, even on the small scale of a few thousand kilowatts installation. The gas companies operating in adjoining territories, even when competitive, do not hesitate to buy and sell their commodity mutually, and the central station can afford to give the problem equally careful consideration.

In the investigation of problems of this kind there is a chance for the scientific study of local situations, and the skilful analysis of operating costs and fixed charges. The gain to the more modern station is possible chiefly through an improved load factor, obtained by superposing the output curves by hours of the two plants and filling up the hollows of the more efficient station's production demand. In a turbine plant where the economy of the station at moderate loads holds up well, there is a special opportunity to show an improved cost of production when the addition of the load of a reciprocating engine station of ancient lineage can be utilized as a higher average load under the new conditions through the lighter hours of the day. The larger the motor load, also, of the less efficient plant, the more likely it is that its addition to the more efficient station will work out as a mutual advantage.

Notes and Comments.

Watershed Patrol to discover any conditions affecting seriously the quality of a municipal water supply is generally recognized to be necessary, but very few water commissions know just how the inspection should be conducted. For this reason there is printed elsewhere in this issue an article on the subject by Mr. Theodore Horton, chief engineer of the New York State Health Department, outlining the general methods to be followed. New York has taken an advanced position in this field of sanitation by providing assistance to any water commission desirous of organizing an efficient patrol. At the request of such a board, a trained inspector from the State Health Department will make a detailed examination of the catchment basin and prepare a full set of rules, adapted to the local conditions, to govern the men in conducting such a patrol. Such aid is decidedly needed, for many boards would gladly order systematic inspection if they knew how to do so, and a little local pressure from physicians could make other boards act. As Mr. Horton points out, however, inspection cannot accomplish everything, and it might be well to supplement it with the system of voluntary inspection adopted by Mr. R. A. Cairns, city engineer of Waterbury, Conn. He has posted notices about the drainage area from which the water supply of that city is drawn offering a reward for promptly notifying him of any unsanitary conditions that may be detected. Such notices are not only constant reminders of the danger that may result from the contamination of the supply, but also serve to stimulate a general interest in preventing the presence of sources of pollution. The actual cash outlay in paying rewards is probably trifling and not to be compared for a moment with the advantages it offers.

The Rapid Transit Situation in New York has recently taken a new aspect. The New York City Railway Company, which controls most of the surface lines in Manhattan, is in the hands of receivers appointed by a federal court. The Public Service Commission, which is a State body, has ordered the receivers to increase the service given by the street cars. The receivers have replied that it would require a capital expenditure of $9,000,000 and an annual charge of $1,400,000 to comply with these orders, and they really cannot raise the money. The commission has declined to modify its orders, however, on the ground that the receivers' lack of funds is caused by their desire to pay high rentals for leased properties. In order to avoid any lack of fairness, the commission has further determined to appraise the value of all the street railway properties in the borough. This undertaking is such a complicated task, involving so many nice points regarding what should and should not be included as "property," that the opportunities for dispute are many and various. For example, there is the question of the "going value" and good-will of the companies; should these things be considered, and, if so, what is their value when the company is in a receiver's hands? Apart from these considerations is the possibility of a clash between the federal court behind the receivers and the Public Service Commission. It is, of course, possible to carry out an appraisal which will be accepted by all parties, for Mr. J. B. Arnold did something of this sort in Chicago, but the chances are great that the appraisal will end in a row. If it is carried out in such a way that the receivers and the commission agree to accept it, the result will go a long way toward untangling the existing snarl in street railway affairs and probably help the people of Manhattan to secure better car service.

Engineering Organizations and the extent to which personality is influenced by taking part in engineering team work were discussed at length by Mr. Walter C. Kerr at the commencement exercises at Rensselaer this week. The address is printed in full in this issue, for it concerns a subject that always arouses controversy. The mere fact of the address being given at the famous Troy college is an indication of a breadth of educational opinion there that some of the oldest graduates may regard with surprise, for it was not so very many years ago that the boast of its alumni was the good preparation for any engineering work afforded by the single course of instruction which was offered. This concentration along one line of teaching has now been abandoned, and one reason for congratulating the trustees on departing from their former course was voiced clearly in Mr. Kerr's address. Engineering is now too comprehensive for any one man to master it, and it is well for all engineers to grasp this fact from the beginning of their studies. It is also highly desirable for engineers engaged in one line of work to keep in touch with those otherwise employed, and it is a fact all instructors have observed that no young man of active mind graduates from a civil engineering course, for example, without having a pretty fair knowledge of the general outlines of the studies followed in the other courses. In commenting on the desirability of having local engineering societies including all branches of engineering and construction work, this journal has frequently emphasized this idea, and the address by Mr. Kerr simply carries it forward to its logical business conclusion. For many years most railway companies and cities have maintained engineering organizations for special purposes, and the evolution of similar organizations for general engineering work has been a perfectly natural development to meet the demands of our time for the technical planning and execution of undertakings too large for the personal direction of any one man.

The National Good Roads Convention which opens on July 6 at Buffalo promises to be a rather unique affair on account of the extent to which automobile drivers will participate in the proceedings. Perhaps one reason for this is their desire to be on hand at the discussion of uniform automobile legislation on the morning of July 7. Just what topics will be debated under that head will depend somewhat on the presiding officer. It is well known that some of the men engaged in the construction and maintenance of good roads believe that the greatest need in the line of uniform legislation is a much higher tax than is now levied on motor cars in any State and a prohibition of tire chains and studded tires except in snow, loose sand and deep mud when driving at a moderate speed is otherwise unsafe. It is desirable to bring about some general agreement regarding the licensing of cars, so that interstate touring will be less subject to legal formalities than it is at present. But it is far more important, in the opinion of most taxpayers, that the owners of automobiles shall pay more than they do now toward the maintenance of roads. There are still some enthusiasts who maintain that the automobile is no more destructive of the surface of macadam road than is a slow-moving truck, but the contrary belief is generally held. Consequently if this subject comes up at the convention and is discussed fairly, a good deal may be accomplished, for the rapid destruction of good roads much used by automobiles is causing many county commissioners considerable worry. The importance of this is recognized, in fact, by those in charge of the convention, and a half day has been set apart for demonstrations of dust-laying compounds and machinery for reducing the cost of road building.

The Prevention of Building Accidents is attracting official attention in Washington, where the floors of an apartment house under construction recently fell, killing two men and injuring five others. The cause of the accident is uncertain, although it seems probable that the flooring was insecurely supported while being put in place, or the brick walls were so green as to yield under the load of the floors and allow the ends of the latter to drop. The cause of the accident is not so important, however, as the apparent determination to secure legislation to reduce the probability of such accidents in the future. Suggestions have been made that only licensed architects and contractors should be allowed to design and erect buildings in the District, but before passing such a law the Prussian building regulations for the same purpose should be studied.

The Westinghouse Electric Works, at East Pittsburg, are so well known to engineers throughout the country that the welfare of the company operating them is a matter of general interest. The troubles of the company during the last six or eight months have been thoroughly ventilated, and it is pretty well agreed that they were due to causes which can be avoided in the future, so that the stockholders and creditors of the company, provided they will exercise patience, may expect not only to secure a return of their money, but may reasonably anticipate a rejuvenation of the corporation in a stronger form than ever. The merchandise creditors have agreed to a plan of reorganization which requires the stockholders to subscribe for new stock in accordance with their present holdings. This plan has been endorsed by those familiar with the prospects of a reorganized company, and it is understood that a large number of the stockholders have already sent in their subscriptions. The time is drawing near, however, when a final decision must be reached, and for this reason attention is called to the desirability of completing these subscriptions immediately. The great works of the company are admirably suited for manufacturing electrical apparatus, but if they are sacrificed at a receiver's sale they will bring in but a trifle. The great organization brought together and trained to design and turn out the famous Westinghouse electric machinery represents a potential capital of great magnitude, and it would be an economic misfortune to see this organization destroyed. Moreover, all users of the apparatus from these works will suffer seriously if the company is wound up, for the practicability of securing repair parts and duplicate apparatus will almost vanish. Consequently, in whatever light the matter is regarded, it is to be hoped that the properties will not have to be wasted by a receiver's settlement.

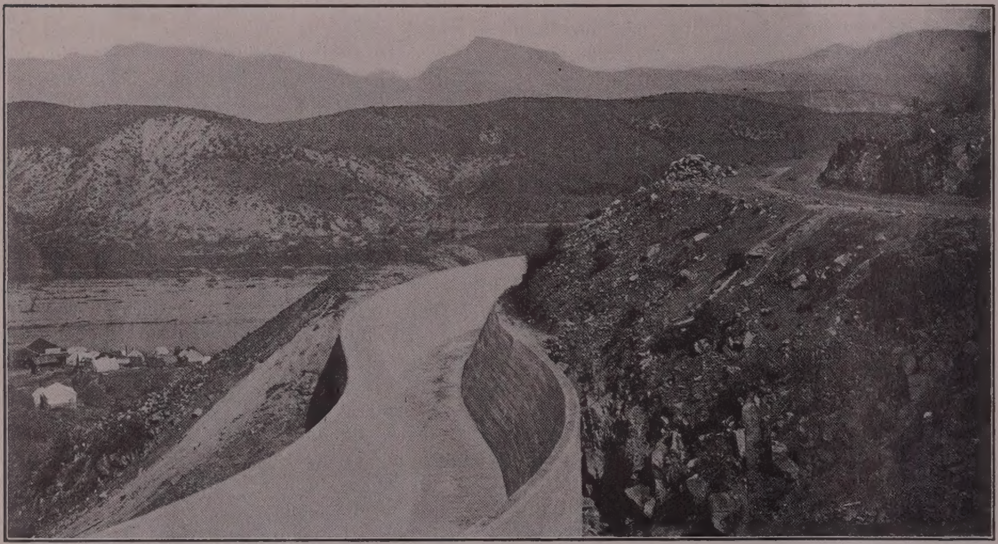
THE SALT RIVER PROJECT.

By A. P. Davis, Chief Engineer, United States Reclamation Service.

Irrigation in Salt River Valley, Arizona, began in 1868, and was gradually developed by the construction of new canals or the enlargement of old ones, until the entire low-water flow of the drier years was appropriated about 1880. Occasional years of plenty occurred, however, and every year afforded considerable floods, which could not be carried by existing canals, so that in 1885 a new canal, called the Arizona, larger than any previous one, was built and gradually brought into use. Soon after this began a series of years of unusually large run-off, and the successive high-water periods, showing a large amount of surplus run-off year after year, attracted public attention and induced the construction of two other canals, the Consolidated and the Highland, bringing the total capacity to an amount more than double the quantity of water available in ordinary years, as shown in Table 1:

Table 1, Principal Canals of Salt River Valley.

Name.	Capacity, Cu. ft. per sec.	Length, miles.	When first used.
North Side.			
Salt River Valley	100	19	1868
Maricopa	175	26	1868
Grand	215	27	1878
Arizona	1,000	47	1885
South Side.			
Tempe	337	30	1871
San Francisco	52	6	1871
Utah	175	20	1877
Old Mesa	175	10	1878
Highland	100	22	1889
Consolidated	600	40	1894



Concrete Flume on Power Canal of Salt River Project.

In 1898, like the backward swing of a pendulum, began a series of unprecedented dry years, the run-off for several years being below the yield during the recollection of the oldest inhabitant. The hot, arid climate makes all crops absolutely dependent on irrigation, and the long-continued drought led to the death of valuable orchards, vineyards and alfalfa fields on which great expenditures had been made. In attempting to save property in all parts of the valley, hardship was caused even to the oldest irrigators with the best water rights. Under these circumstances the Legislature of Arizona provided for preliminary investigations of the feasibility of water storage on the upper Salt River, which were carried out in co-operation with the United States Geological Survey in 1901. Under the direction of the writer a large reservoir site was surveyed, foundation for a dam explored with diamond drills, and the feasibility of the entire plant investigated.

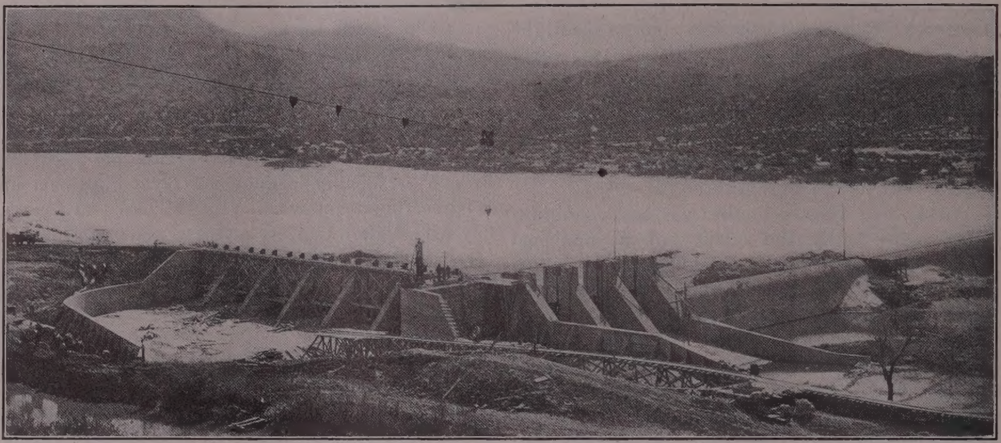
Unusual difficulties were presented by the isolation of the locality and the extreme roughness of the surrounding topography, which was of volcanic origin and scored by profound box canyons. Those conditions made it extremely expensive to import heavy articles, such as cement and fuel. Investigations revealed the presence of suitable materials for the manufacture of cement at the dam-site, but the large quantity of fuel required for the necessary power for manufacturing the cement and building the dam presented great difficulties. The little wood available was scattered and of poor quality. It was decided to develop water power by diverting the river and carrying it through canals and tunnels for a distance of about 18 miles and dropping it 250 ft. The towns of Phoenix and Mesa co-operated in the construction of a road, and over this road is freighted oil from California, which is used for burning the cement, and water power is used to run the mill and to excavate and handle materials for the dam.

Table 2, Cost per Barrel of Cement Manufactured at Roosevelt Plant.

	February.	March.
Superintendent and chemists	$0.037	$0.031
Operating labor	0.284	0.276
Maintenance labor	0.028	0.034
Maintenance material	0.053	0.113
Clay digging	0.050	0.050
Clay hauling	0.067	0.063
Quarry expense	0.128	0.131
Material and supplies	0.013	0.050
Fuel, wood	0.105	0.072
Fuel, oil	0.970	0.925
Electric power	0.079	0.090
Total	$1.814	$1.835
Output, barrels	10,614	12,016

Average cost per barrel, February and March, $1.826.
Average daily output, 377 barrels.

The progress of the contractor on the dam has never required the full output of the mill, and it was never run at full capacity until January, 1908. The following Table 2 gives the output and cost during February and March, showing a cost of $1.826 per barrel, of which more than half is the item of oil, imported from California, for use in the kilns. The wood fuel is used in the rotary dryers. To these costs should be added about 60 cents per barrel for the plant, and a small amount for general administration. Two dollars and fifty cents per barrel will be a liberal estimate for the entire quantity required. This is less than half what it would have cost to purchase and haul in the cement.



Intake, Sluiceway and Gates of Granite Reef Dam.

The little sand that occurs in this vicinity is badly mixed with adobe mud and is of very poor quality. It was found that a much higher grade of sand could be manufactured by crushing dolomite, which occurs conveniently near the dam site, so a mill was erected for this purpose. The cost of sand crushing for February and March is shown in the following Table 3:

Table 3, Sand Plant Operation.

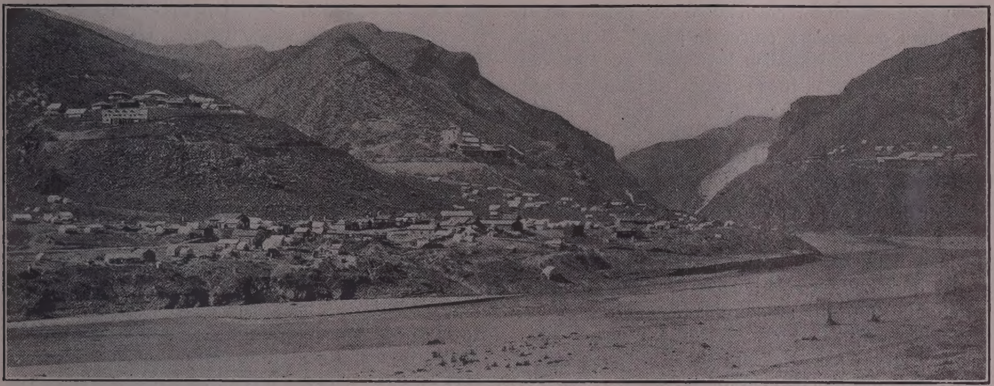
	Cost per yard.	
	February.	March.
Superintendence	$0.13	$0.014
Labor, operating	0.214	0.214
Labor, repairs	0.007	0.016
Materials and supplies	0.163	0.027
Power	0.04	0.044
Quarry expense	0.81	0.657
Depreciation	0.30	0.300
	$1.547	$1.272
Yardage	2,885	2,668

In the foundations of the various mills and buildings large quantities of lime were used, which were also burned at the dam site. Such works as these always require large quantities of lumber for concrete forms and temporary works of various kinds. It was found feasible to install a saw mill in the neighboring mountains for this purpose, and about 3,000,000 ft. of lumber have been sawed and delivered on the work. Several kilns of brick were also burned for use in various parts of auxiliary structures.

The storage dam on Salt River is to be built just below the mouth of Tonto Creek, where the river flows through a profound gorge. From foundation to coping the dam will be about 283 ft. high, and the reservoir will have a capacity of about 1,300,000 acre feet. The power developed for the construction of the dam will, after its completion, be transmitted to the valley for pumping water from wells to increase the water supply for irrigation. Arrangements have also been made for transmitting a portion of this power to the Gila River Indian Reservation for supplying the Indians with irrigation water by pumping.

The contract for this dam was let to James O'Rourke & Co., of Galveston, Tex., in April, 1905. Since the contractor began work an unprecedented series of excessive floods have greatly hampered the work, having washed out the contractor's coffer-dam four successive times and filled up excavated portions of the foundation. The contractor has, however, succeeded in placing the foundation in the river and in bringing the upstream portion of it to the top of his coffer-dam, so that such disasters are not to be feared in the future.

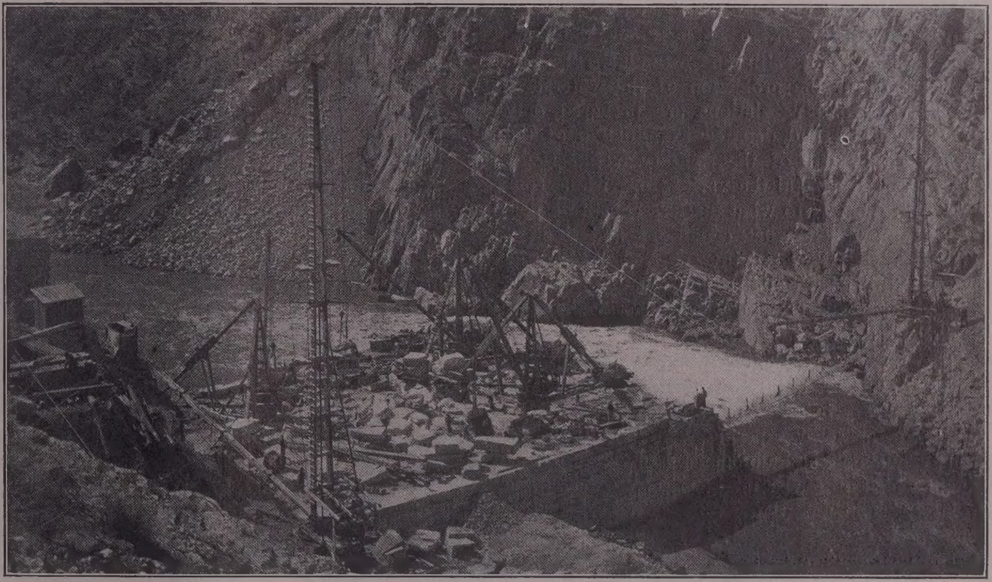
The great flood of November, 1905, also washed out the Arizona dam, just below the mouth of Verde River, which served as a diversion dam for the Arizona Canal and the other canals on the north side of Salt River. This north-side system was purchased by the Secretary of the Interior with reclamation funds in 1906, and a concrete dam for diverting water into it is being constructed at a granite reef, below the old Arizona dam. The entire canal system on the north side of Salt River, serving at present over 60,000 acres of land, is being operated by the reclamation service, a temporary dam being maintained in the river at the head of the canal, pending the completion of the concrete structure below.



General View of the Dam Site from the Upstream Side.

Water is to be drawn from the Salt River Reservoir through a tunnel closed by three gates, the opening of each being 5 x 10 ft. They are a combination of steel and bronze, of the Stony type, moving on rollers, and closing against bronze seats having a batter, so that the gate comes to a bearing on the seat just as it is closed, and when opened, the pressure is taken by the rollers as soon as the gate starts. The gates will be operated by hydraulic cylinders electrically controlled. No other instance is known where gates of this size are operated under so high a head.

The storage system under construction is expected to serve an area of 180,000 acres of land in this valley, which can be increased by the extension of pumping development with the power available from the project until the limit of the underground water supply is reached. The reservoir dam is 34 per cent. completed; the Granite Reef dam is 80 per cent completed. The Salt River project, as a whole, is 67 per cent. completed.



Upstream Face of Dam, Salt River Project, on March 2, 1908.

Mr. Louis C. Hill is supervising engineer for the Reclamation Service in Arizona and adjacent States. The construction of the Roosevelt dam is under the immediate direction of Chester W. Smith, constructing engineer.

A MAINTENANCE CLAUSE in a paving contract for work to be done at Jamestown, N. Y., has just been declared invalid by the Appellate Division of the Supreme Court of that State. The decision is, in substance, that where a city charter required the cost of the original pavement only to be paid by the abutting property owners, leaving the city to bear the expense of repairing it, a contract which required the contractor to make repairs for ten years necessitated not only by defective materials and workmanship, but also by the action of the elements, placed the burden of maintaining the pavement on the property-owners and was therefore void, in the absence of evidence that with proper construction and material the original pavement would last for the period covered by the guaranty. It was further decided that the burden of proof was on the city to show that, with proper construction and material, the original pavement would last for the period stipulated in the contract.

Sanitary Patrol of Watersheds.

A paper in the "Monthly Bulletin" of the New York State Department of Health, by Theodore Horton, Chief Engineer and Director of the Division of Sanitary Engineering.

In the State of New York there are in round numbers some 350 public water supplies derived from surface or underground sources. Of these supplies about 200 are derived from driven wells or natural springs; about 50 from lakes, ponds or artificial reservoirs; and about 100 from rivers, brooks and other running streams.

The protection of these supplies against pollution and possible infection is a duty of grave importance, one which unfortunately is not always fulfilled with the responsibility and exactness that its importance demands. Nor is this to be wondered at when we consider that these supplies are generally controlled by civic boards or private water companies preoccupied by numerous duties of an executive or administrative nature, and these restricted for the most part to the territory within the limits of their distribution or piping systems. But however multifarious and pressing these duties may be, there can be no adequate or extenuating excuse for neglect or failure to exert every possible effort to prevent a contamination of the watershed which furnishes the water for these supplies.

It occasionally happens, however, that with the best apparent intention and the exertion of conscientious efforts and the expenditure of labor and money, the measures often followed prove ineffective, either through a lack of adequate knowledge of sanitary principles or a lack of that necessary foresight and action which at a critical time might have averted an epidemic. It is, then, with the purpose of pointing out to the practical water works superintendent under whose immediate supervision all protective measures are executed, and to the health officer to whose general custody the public health of the entire community is intrusted, some of the more important factors and duties involved in an efficient sanitary patrol of a watershed, that the following discussion is offered.

In the first place, systematic inspections are absolutely essential if a thorough protection of the water supply is to be accomplished, for, unless it is thorough, the very end which is sought may be defeated. These inspections should be made as often as once each month on smaller watersheds, and in the "danger zones" of the larger ones, and never less than four times a year. In the latter case the times of inspections should be so selected as to include those seasons when pollution is likely to be more intense, such as for instance during the late winter or early spring when the melting snow and ice may wash a large amount of pollution over the frozen and impervious soil into the stream, which, being swollen, may carry infection directly and swiftly to the intake. Again it is well to make an inspection during the season when the farmers are fertilizing their fields by spreading manure or night soil upon them. Or if the watershed is frequented by summer visitors, an inspection at that time may reveal overflowing cesspools or possibly unexpected temporary pollution.

It is impossible to formulate a set of rules for guidance in this class of work applicable to all watersheds, for each watershed represents a special case depending upon local conditions. We may say in general, however, that the attention of an inspector should be focussed upon two objective points; first, the detection and removal of cases of pollution; and second, the detection and proper quarantine of any positive or suspected cases of typhoid fever or other water-borne diseases on the watershed. Even though no cases of pollution exist, the danger from the presence of a typhoid fever case should be a signal of warning, and a sharp espionage should be maintained to see that every barricade is set up to prevent any possible further spread of the disease and possible infection of the supply. These precautions should not be taken on faith, but should be carefully and frequently inquired into and the health officer promptly notified.

It is assumed that the superintendent or the inspector is sufficiently familiar with the customary methods and arrangement of means for the disposal of human wastes and refuse to enable him to search out all points of pollution. These questions of fact are relatively a simple matter. The more difficult questions which may and probably will arise, are as to what extent do any conditions found to exist create a menace to the supply and what means are at his disposal to remedy these conditions.

As to the question of possible menace there may be found many conditions about which there will be little or no doubt, e.g., either from the character of the waste material or the method or manner in which these may reach the water supply, there will be no doubt as to whether the conditions will or will not be a menace to the supply. On the other hand there may be found cases of pollution wherein a decision may be very difficult, e.g., it may be a questionable location of a pig pen or a pile of manure or garbage; or the location of a privy or cesspool; or again it may be a question of ice cutting or bathing; or of the spreading of night soil upon the ground for fertilizing, or of a cemetery. The question as to what extent these conditions may create a menace to a water supply is not always simple of solution; and even when there may be little scientific doubt as to the danger of any particular case it is frequently a difficult matter in practice to remove or correct the condition.

Very fortunately for the local water boards and companies, there is provided by the State Department of Health, acting under statutory law, means which make the solution of these questions and the abatement of the conditions much simpler than could be possible with the more ordinary means and common law locally available. The Public Health Law provides that, when application is duly made by a local board or company having charge of a water supply, the State Commissioner of Health may formulate rules and regulations for the protection of the watershed. These rules and regulations are prepared only after a careful and detailed examination of the watershed by one of the sanitary engineers of the Department; and the various provisions contained in them as to what matters constitute pollution, and under what conditions and limiting distances pollution of different classes shall be permitted in the vicinity of streams or watercourses, are all definitely and specifically embodied in the rules.

The fact that these rules and regulations are specific in their nature—in fact, apparently almost arbitrary in order to be specific—makes the work of the local superintendent and inspector relatively simple and eliminates many questions of doubt which otherwise might arise. In fact, these rules serve in nature not only as a health ordinance, similar to those of every local health board, but they are usually so definite and explicit in their description of different classes of waste matter, and so clear as to the relative danger of each class as a source and spread of infection, that they afford at the same time a code of instruction, or a manual, to guide the superintendent or his inspector in his field work.

It was thought not very many years ago that organic pollution of any nature was a menace to a water supply, and the rules generally in force in those days seemed to be framed with this view in mind. At the present time, however, and in view of our more enlightened knowledge of the germ theory of causation and transmission of diseases, we are forced to take a more rational view, and distinguish sharply between those classes of pollution that are fundamental causes of disease transmission and those other classes which give rise only to offensive odors, or other objectionable conditions, but which have no direct relation whatever to the causation or transmission of disease. I say direct relation, for almost any organic matter that has no inhibiting chemicals or poisons in it may furnish food for disease germs and consequently aid in the multiplication, or at least prolongation of the life of these germs.

In short, one must always bear in mind in matters of this kind, not in an incredulous way, but in a clear and practical way, that typhoid fever can be transmitted only by means of specific typhoid bacilli. These bacilli are human parasites, which develop and multiply in all probability only within the human system, and a typhoid infected water supply can only become infected by typhoid fever bacilli that have lived and developed in the human body and left their host, and, through carelessness or ignorance, escape through the successive barriers that may or should have been set up and carefully maintained by the attending physician in the sick room and the household, or by the health officer or the water works superintendent or other sanitary agent on the watershed, and find their way into the water supply.

In more specific terms, the water works superintendent or sanitary officer in patrol of a supply must learn to distinguish between, and take consistent action upon, those classes of pollution such as pig pens and manure piles, and piles of rotting vegetables, or fruit, which in themselves are harmless as a source of transmission of disease; and those other classes of wastes derived from human origin such as discharges or leakages from sewer drains, cesspools and privy vaults. The former may be unsightly and offensive to the smell and truly objectionable from an æsthetic standpoint, and the public may through ignorance denounce them as a danger and menace to life; yet it is the latter, through their ofttimes hidden and surreptitious channels of discharge, that contaminate and occasionally infect a water supply and give rise to the dreaded epidemic. Let it not be forgotten either that sometimes the harmless appearing manure pile may be the receptacle of typhoid dejecta, with all the hidden danger this implies, or that a newly plowed field may have been fertilized with manure of man as well as beast, and that the rains of spring may wash this manure with its infected material directly into the water supply.

Because certain matters of organic nature are harmless as a source or means of infection, and others of human origin are harmful, it must not be inferred that any license or tolerance should be given the existence or maintenance of pig pens, manure piles and garbage near a watercourse of a supply, for they must not be. A water supply should be not only "safe" but it should also be "wholesome" and clean—as free from turbidity, color, odor and pollution of any character as it is possible to secure and maintain. Some of these characteristics can only be secured by purification, but with a surface water generally satisfactory with regard to turbidity and color, it lies largely with the water works management to secure a freedom from odors and pollution. This implies a restriction or prohibition against any act or condition that allows waste matter of any character to reach the watercourses of a supply. The restriction against all wastes of human origin is then absolutely mandatory for the full protection of health and life of those using the supply, while the restriction against all other wastes or pollution is essential to the wholesomeness, cleanliness and attractiveness of the supply.

Although the foregoing statements apply more especially to water supplies taken from surface sources, they are also applicable in a large measure to supplies taken from underground sources. In the latter cases, however, the channels by which the pollution may reach the underground supply are so varied and variable and so difficult of detection, and depend so largely upon local underground conditions that cannot be learned by inspection, that rules and regulations for their protection become impracticable. This does not mean that they cannot be safeguarded nor that sanitary patrol should not be instituted. Quite the contrary, for it is the very uncertainty and difficulty of detecting the real sources of pollution that makes precautions all the more necessary. The principles of protection and methods of patrolling the watershed tributary to the wells or springs are the same as for surface supplies, the channels of pollution taking similar, though not identical, courses to those on the surface. The underground pollution, passing through the soil, may or may not become thoroughly purified, depending upon the geological formation and other local conditions, and it is this uncertainty that frequently requires the evidence of chemical and biological analyses to settle. Except under unusual conditions, however,, a knowledge of surface conditions of a watershed will usually be sufficient to indicate any danger from underground pollution.

There are a few points of especial importance in care and patrol of underground supplies that should be pointed out, and the neglect of them has occasionally given rise to serious results. The first point to be borne in mind is that the most probable and serious source of pollution is from the surface. Polluted streams may pass near or over wells or springs, or surface washings which may be and frequently are polluted, may enter the top of a well or travel along the driven pipe; in fact, many other possible means of surface pollution may directly reach the underground supply, so that the first and most important step in safeguarding these supplies is to so protect the surface of the ground immediately adjacent to the wells or springs in a manner that will prevent any possible surface pollution from reaching the water.

The next danger to these underground supplies is of course sub-soil pollution. Physical conditions will generally indicate the possibility of dangerous pollution. If the ground is sandy and filtration good, there will be little danger of any contamination of supply if the sources are few and remote. If, however, the territory is rocky, or if there are sources of pollution in proximity to the supply, the case is more difficult and uncertain and it will usually be necessary to resort to analytical evidence. In these cases the analyses may in a measure be considered as taking the place of sanitary inspections of the watershed, and should be made with the same frequency as these surface inspections; for well water may vary with respect to pollution from season to season according to local characteristics of the soil. In general, then, we may say in regard to underground supplies that precautions against surface pollution, the removal of all sources of underground pollution in the neighborhood of the wells or springs, the frequent analyses of water in cases where conditions are doubtful, and the ever careful espionage and action in case of any positive or suspected cases of water-borne diseases on the watershed tributary to the wells or springs, may be considered the key notes to successful protection.

A word should be said in regard to those supplies taken from large streams and rivers having large watersheds. Many of them are so large as to make efficient patrol expensive or impracticable. When we consider that any direct pollution of human origin is a menace to a supply, the futility of effectively patrolling a large watershed having a number of communities situated upon it is apparent. The problem in these cases comes down to one largely of chance which, unfortunately, has been taken by many municipalities with disastrous results. The epidemics in the cities on the Merrimac, Androscoggan, Hudson and Black rivers are ample testimony of the truth of this principle, and the protection by means of water purification adopted by many of the suffering communities seems to have given the final proof that effective patrol is not only impracticable but that the only full protection in such cases is purification.

In conclusion, then, it may be said:

(1) That where patrol is possible and practicable, which is usually the case with all surface

supplies having watersheds of moderate areas, whether surface or ground water supplies, it must be done with regularity and thoroughness if it is to be effective.

(2) That prohibitions against all pollution of human origin are absolutely essential to a full protection of a supply against disease infection, and prohibitions against all pollution of any character are necessary to preserve a supply in a clean, wholesome and otherwise satisfactory condition.

(3) That the means or channels of infection are almost innumerable, and that it is only by a careful study of the possible means of transmission of infection, and of the local conditions of a watershed, that the danger spots thereon can be discovered and either eliminated or controlled.

(4) That chemical and biological analyses afford valuable evidence of the pollution, and should be occasionally and regularly made for all supplies, and at frequent intervals where any doubt exists as to presence or character of the pollution.

(5) That house to house inspections should be made at frequent intervals to discover any positive or suspected cases of typhoid fever or other water-borne diseases, and, should any cases be discovered, special and immediate steps should be taken to institute a quarantine and set up barriers that will prevent any possible infection reaching the supply.

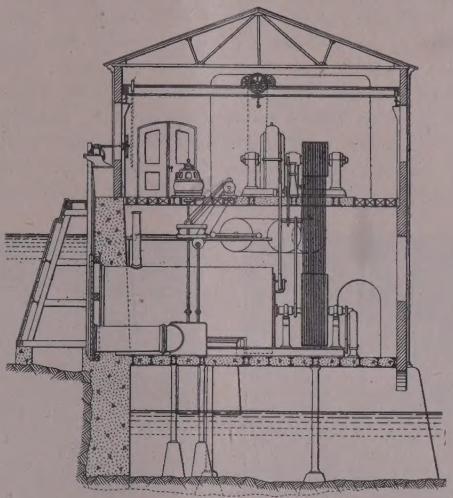
I believe that if the sanitary patrol of our watersheds be carried out with regularity and thoroughness, and with especial attention given to the points or factors suggested above, the prevalence of water-borne typhoid fever and other diseases, unfortunately too common in many of our communities, will not only be greatly reduced but largely eliminated.

The Cost of Handling Coal from vessels or barges to the furnaces of power plants varies, according to a paper presented by Mr. E. G. Bailey before the Boston Society of Civil Engineers, from as low as 18 to 20 cents to over $1 per ton. The above low figures are attained only in large plants equipped with coal-handling machinery and mechanical stokers that receive coal in barges, the corresponding cost for large modern plants receiving their shipments by railroad cars being 25 cents per ton. In the smaller sizes of plants where coal is unloaded from cars, passed and fired by hand, the cost is stated to vary with differing conditions from a minimum of 40 cents to as high as $1.25 per ton.

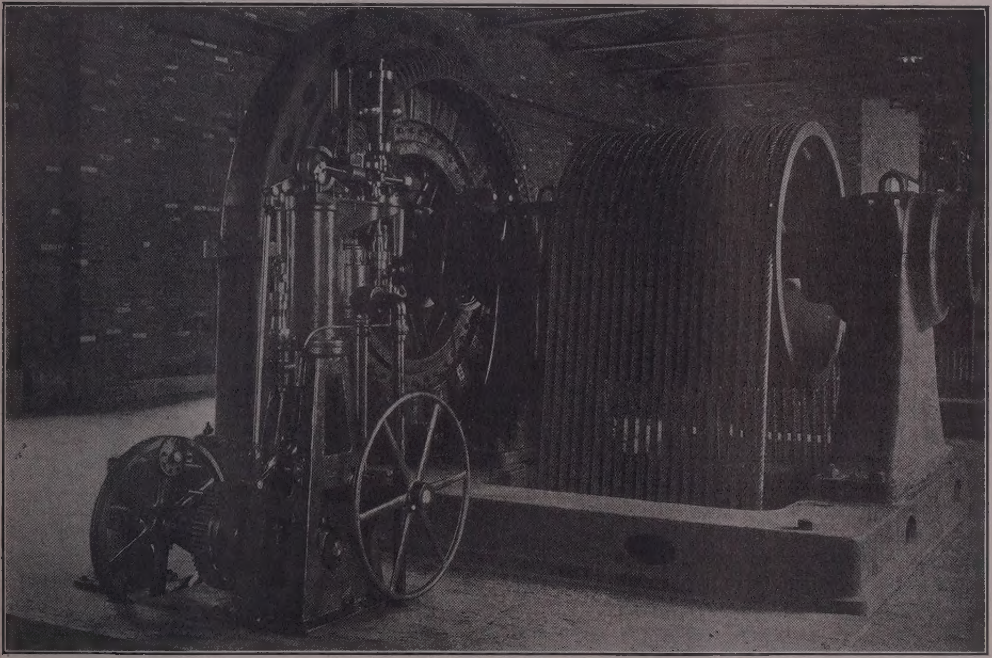
The Hydro-Electric Power Plant of the Winchester & Washington City Railway Company.

By N. Wilson Davis, M. Am. Soc. C. E.

There has just been completed on the Shenandoah River, a hydro-electric plant which furnishes light and power to Charlestown, W. Va., Berryville and Winchester, Va., and will eventually operate an electric road from Winchester to Bluemont and Washington. The design of this plant was formulated, so to speak, from local conditions; even the character and quality of easily obtainable materials for construction being a large determining factor in originating the plans, but only the salient features will be mentioned here.



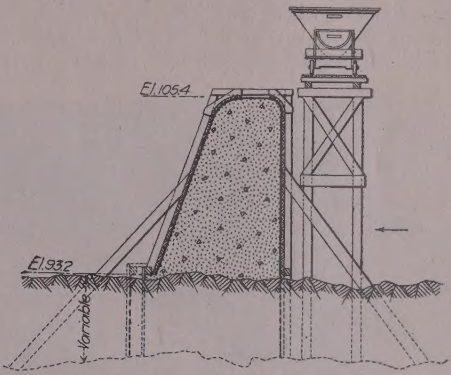
Section of Power Station.



Rope-Driven Generator and Governor.

Topographical conditions determined the location of the dam at the head of the rapids, where a comparatively low dam could be built at the narrowest point between two solid rock bluffs and a continuous ledge of slate runs flatly across the river, affording an excellent foundation at depths varying from 2 to 8 ft. below the water. Here the water could not be raised more than 12½ ft. without interfering with a water power above, which determined the height of the dam, and the natural fall in the river of 11.9 ft. limits the total available head to 24.4 ft. The alternate proposition of building a high dam at the foot of the rapids was rejected on account of the extra width between bluffs, greater difficulty in securing proper foundations and increased cost. The head and tail races had to be located at the foot of steep slate bluffs and practically in the bed of the river, which necessitated building heavy rubble masonry and stone-filled concrete walls, backed by loose stone and quarry waste from the rock excavation in the head race and the wheel pits, in order to retain the water and afford protection from floods.

The geology of this section indicates limestone, slate and quartzite, in the order named, from west to east. At the river the bed rock, though quite fissile, is a very firm close-grained slate, and as its cleavage is oblique to the stratification it forms a good "saw-tooth bond" for the foundation of the dam and race walls. The limestone was not an easily available material for construction because it lay too far west and beyond the steep slate hills that formed the river bluffs. The slate was an unsatisfactory material for concrete owing to its tendency to break into flakes; this was obviated practically by crushing it finer than usual. Nor was the slate suitable for rubble masonry, breaking into rhomboidal stones at every attempt to quarry it, which permitted this material to only be used in stone-filled concrete.



Section of Dam and Mold.

In searching for a suitable material to form the aggregate for the concrete, a large bed of quartzite gravel was discovered about ¾ mile above the location of the dam; and test pits proved that there was not only gravel in sufficient quantity but also a large admixture of sand. It was then determined to build a solid concrete dam of this material, obtaining additional sand from other sources.

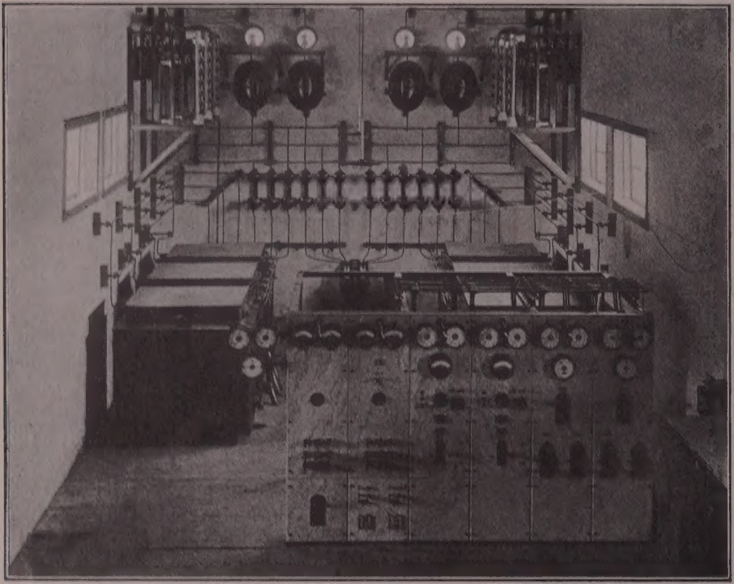
The gravel was hauled in tram cars, hoisted up an incline to a point about 40 ft. above the crest of the dam and delivered to revolving screens that divided it into four grades; 1, sand; 2, fine gravel with some adhering sand; 3, medium gravel, 1 to 1½ in.; 4, coarse gravel, 2½-in. size.

The very coarse gravel and boulders were delivered to the crusher, and the stone thus broken formed about a fourth part of the total mass and apparently furnished enough "roughness" to insure a good mechanical bond where cracks might be formed by contraction. Movable tongues were placed in the chutes to divide and grade the screenings properly and to discard the dirt often mixed with the gravel.

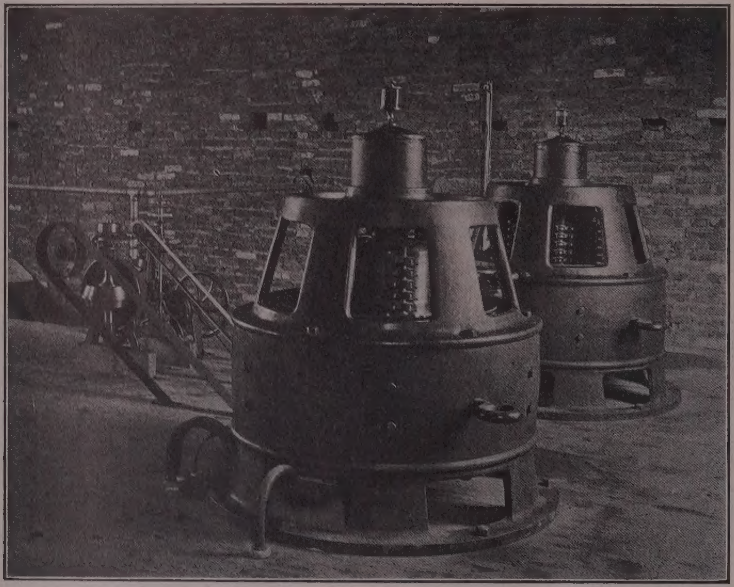
The concrete was mixed in the proportion of one part of Portland cement to two and one-half parts of sand and five parts of gravel; but when this mixture was placed in deep narrow forms there proved to be an excess of mortar, which was corrected by reducing the sand and adding more fine gravel. The causes of this condition in the concrete were: (a) the uniform grading of the gravel, by screening, which reduced the percentage of voids in the aggregate; (b) the clinging of some sand to the gravel after it had passed the screens; (c) the shape and smoothness of the gravel which enabled them to be closely packed, and, (d) the fact that a slow-setting cement was used which permitted quite a depth of concrete to be placed in the forms before any of the mass began to harden and thus the smooth gravel, in the process of handling, shovel-facing and tamping, would constantly work into a very dense mass. The Dragon brand of Portland cement was used throughout this work and slow-setting was a requisite so that the weight of the concrete would aid in compacting itself before it began to harden. Repeated tests of the cement showed the time of the initial set to be from one to two hours.

The opportunity for using this process was afforded by the fact that the foundation could be entirely freed from water with reasonable ease and well cleaned with wire brooms and hose before any concrete was placed. The result was a very dense, uniform and almost water-tight concrete.

One of the accompanying diagrams shows a section of the dam and the arrangement of the form timbers, where simplicity was made a feature of the design so that the forms could be readily and accurately built by ordinary workmen and also easily removed to be used again without cutting the timbers.



Switchboard and Transformer Room.



The Exciters and their Governor.

The dam was from 14 to 18 ft. high and 985 ft. long, with a spillway 761 ft. long by 6 ft. deep designed to carry a flood equal to a 12 ft. rise in the river without overflowing the abutments at the head gates. Other features of interest are shown on the drawings and photographs.

The location of the dam at the head of the rapids was favorable to the use of light deflection dams instead of cofferdams, except in a few deep holes, for the water when deflected would ordinarily flow away and not back up on the work from below. The water was deflected to the opposite side of the river and the head gates were first built; then the water was turned partly through the head race and partly through a 50-ft. opening left for the purpose. This opening was finally closed by building an A-shaped cofferdam, which was floated into position so as to straddle the opening, and sunk.

The government records of the flow in the Shenandoah, from a drainage area of 2990 square miles, indicate that 2000 h.-p. will be available at ordinary low water, excluding extreme drouths, and upon this basis the plant was designed with 3600-h.p. capacity in turbine wheels and 2150 k.w. capacity in generators and exciters, at 100 per cent. load factor. Since this power will supply the prospective market there has been no provision for an auxiliary steam plant.

The peculiar character and location of the market for power determined the methods of development and transmission. Charlestown is 5 miles from the plant, Berryville 16 miles and Winchester 26 miles; all located on the same transmission line, and the primary voltage, required for Winchester, was made the same at all substations. It is estimated that the total night load will not exceed 500 k.w., and therefore the plant was subdivided into four generating units of 500 k.w. capacity each; thus a fairly high load factor may be maintained by cutting in or out a unit to suit the demand and the load may be divided between two or more units during freshets, whenever the head is diminished enough to affect the speed of the generators.

The turbine equipment consists of four units, each having two 45 in. Leffel turbines mounted on a horizontal shaft and set in a flume of boiler iron 12 ft. in diameter with a center discharge and a short draft tube 9 ft. in diameter. The shaft extends through the head of the flume and is provided with a grooved sheave 9 ft. and 6 in. in diameter with a 42 in. face having twenty V-shaped grooves suitable for a rope drive. Each unit is guaranteed for an efficiency of 80 per cent. or to deliver 850 h.p. under an effective head of 22½ ft., at 170 r.p.m. with a discharge of 25,200 cu. ft. per minute.

The speed of the turbines is controlled by a Type Q Lombard governor provided with a small electric motor to operate a valve, and so arranged that the speed may be delicately regulated from the switchboard when the generators are being synchronized.

The American type of rope drive was selected, using an endless manila rope 1½ in. in diameter with a lubricated core. The diameters of the sheaves were so adjusted that their peripheral speed, on the pitch line, would not exceed 5000 ft. per minute. Rope drives were adopted to avoid the extra expense of installing direct-connected slow-speed generators of abnormal size and unusual design and on account of the difficulty of making absolutely water-tight compartments to protect the generators from the frequent floods. The rope drives are protected from high water by galvanized iron boxes that enclose the lower part of the sheaves as shown on the drawing.

The turbine equipment also includes two independent 20-in. Leffel wheels mounted on vertical shafts and provided with flexible couplings for the direct-connected "umbrella type" exciters. One of these turbines turns clockwise and the other counter-clockwise so that only one type D Woodward governor is required to control both wheels and a simple arrangement of friction clutches admits of either or both wheels being operated at will.

The entire electrical equipment, including the substations, was furnished and installed by the Westinghouse Electric & Mfg. Co. There are four revolving-field, three-phase alternators of 500 k.w. capacity each, at 60 cycles and 360 r.p.m., generating current at 2200 volts. The generators are arranged to run in parallel and provided with three bearings and a sheave pulley suitable for the rope drive.

It is intended that three generators shall supply the market for power and the fourth is to be held in reserve in case of accident or to be thrown into service during freshets when it will be necessary to divide the load between the power units.

There are two exciters of 55 k.w. capacity at 125 volts and 350 r.p.m., provided with a flexible coupling for direct connection to the vertical shaft of the 20-in. turbines. Either exciter is arranged to operate with one generator alone, or with any three in combination, and furnish light for the buildings.

The leads from both exciters and all generators are carried in fibre conduits underneath the floor to the low-tension switchboards.

The switchboard contains two exciter panels, four generator panels and two power panels, all of blue Vermont marble and provided with a full quota of instruments, two sets of busbars and three distant-control oil switches.

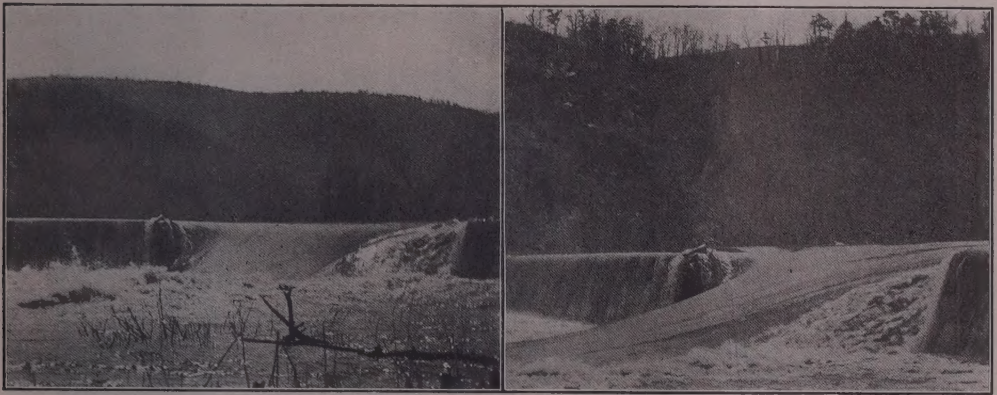
Immediately back of the switchboards is the transformer room in which there are two banks of oil-insulated, self-cooled transformers, each bank containing three 250-k.w. transformers wound for 2200 volts primary and 22,000 volts secondary at 7200 alternations. Here are also placed the rheostats for the generator panels, the distant-control oil switches, the low-equivalent static discharges and disconnection switches for both out-going transmission lines.

Provision is made at the switchboard for throwing any generator on either bank of transformers and for throwing either bank of transformers on either transmission line; and every effort has been made to insure the ready interchange of units and such flexibility that the plant may be adapted to any condition of load likely to arise.

The transmission line, which carries a 22,000-volt current, consists of two three-phase circuits, each having three strands of No. 4 hard-drawn copper wire placed 30 in. apart at the apices of equilateral triangles and supported by Locke high-tension insulators. The poles are of chestnut with long cross-arms attached in the ordinary manner, and they vary in height according to location; those poles crossing open fields are usually 30 ft. long and 110 ft. apart, while on public roads, streets and at railroad crossings 40 and 45-ft. poles were used so as to carry the high-tension wires well above all telephone and telegraph lines. At all railroad crossings a special woven wire protector 10 ft. wide was stretched across the tracks underneath the high-tension wires and grounded on each side of the track; here the poles were extra heavy and specially guyed with galvanized wire.

The transmission line has a length of 25 miles, with substations at Berryville and Charlestown provided with reducing transformers and distributing switchboards that deliver current to the commercial lines at 2200 volts.

The accompanying cross-section of the main station was taken through the exciter wheel room, with one partition wall removed to show the generator unit in the adjoining room. It should be noted that the lower part of this building containing the wheel-pits and wheel rooms is divided into five compartments by 3-ft. partition walls of concrete placed 20 ft. between centers, that furnish foundations for the turbines and generators which are supported on heavy I-beams, as shown. These walls extend up to the level of the floor line of the generator room and abut against the head wall, which fact permits the use of a rather thin head wall. The service gates are controlled from the inside of the building, as shown on the plans.



The Contraction of the Water Passing through the Unclosed Dam.

This plant is already lighting the three towns named; and as much as 500 h.p. has been sold to woolen mills, pulp mills, printing offices and a large dolomite quarry, which indicates that the market for power will exceed all that has been expected of it.

The company owning the plant was originally organized to build an electric railway from Winchester to Bluemont, Va., a distance of 28 miles, crossing the Blue Ridge Mountains through Snicker's Gap and connecting with the branch of the Southern Ry. from Bluemont to Washington City. It is evident that the proposed road, crossing the barrier of the Blue Ridge Mountains, offers marked advantages to the counties of Frederick, Clarke and Loudoun, but since the charter of the company permits the furnishing of electric power for lights and manufacturing as well as for railways, the engineer advised, as the first step in this enterprise, the development of the water-power and its utilization for lighting and manufacturing purposes, which would produce quick returns and place the foundation of the whole project on a paying basis before venturing further.

The present plant, transmission lines and equipment has cost approximately $264,000 and until the present development is self-supporting, the company will proceed very deliberately upon the construction of the electric railway, which is roughly estimated to cost $300,000 additional. Rights of way for the proposed railway have already been obtained from Winchester through Berryville for a distance of about 12 miles and the transmission line is now placed on the edge of this right of way with a view of ready access when the railway is built.

The Port Works at Havre, France.

The improvement of the port of Havre that was undertaken in 1896 is now practically completed at a total cost of about $11,500,000. The new works, according to "The Engineer," of London, include the following: 1. Two stone masonry breakwater piers forming a large outer harbor. 2. The dredging of this outer harbor and a new entrance to it to a depth of 19.7 ft. below a datum plane, which is about 1 ft. below extreme low tide, 3.3 ft. below ordinary spring tide and 14.1 ft. below mean sea level. 3. The construction of a new entrance lock giving access from the original outer harbor to two inner basins formerly accessible only at high water.

The two breakwater piers forming the outer harbor both start from the shore, with their ends about 4,700 ft. apart, and converge to an entrance 656 ft. wide. One of these piers is about 2,790 ft. in length, the inner 656 ft. of it being on a concrete footing, while the remainder has a rubble base. The other pier has a total length of 2,880 ft. Each pier terminates at the entrance to the harbor in a head 98 ft. long, both of these heads having been seated at a depth of 4.2 ft. below the datum plane by means of caissons. The hearting of the rubble base of the piers consists of stones weighing from 90 to 2,200 lb. and averaging about 450 lb. This hearting is covered with stone blocks ranging from 2,200 to 11,000 lb. each and averaging about 5,500 lb. Where the foundation of this base is higher than 6.6 ft. below datum, it is also covered with rough stone blocks ranging from 11,023 to 22,000 lb., and averaging about 15,400 lb. When the foundation is at levels more than 6.6 ft. below datum, the outer covering of the base consists of concrete blocks weighing 36 tons.

The lower part of the superstructure of the piers consists of a course of concrete blocks 13.12 x 10.5 x 6.56 ft. in size, which were cast on the shore. These blocks were laid with a space of 2 to 2.3 ft. between them, which space was filled with concrete, giving the footing a width of 24.6 ft. The superstructure, which was built in place, is 16.4 ft. wide at the top, both side walls being battered 1 in 10. A parapet 4.26 ft. thick and 4.92 ft. high is formed on the sea face of the walls.

At the shore end of one of the breakwater piers a deep-water quay has been built to provide berths for the largest class of transatlantic steamships, accessible at all stages of the tide. The quay wall is 16,400 ft. long, the channel in front of it having been dredged to a depth of 30.5 ft. at extreme low tide. A site for a harbor and railway station has also been provided in connection with this quay by the construction of a wall 13,490 ft. long, parallel to the latter and a cross wall 213 ft. long, connecting the two parallel walls.

The quay wall has a total height of 72.18 ft., is 39.37 ft. wide at the base and 5.74 ft. wide at the top, the width being reduced by a batter on the front face and by steps in the rear face of the wall. The mass of the latter consists of stone masonry in lime mortar, with a facing of dressed granite laid in Portland cement mortar. The wall is founded on fourteen steel caissons, sunk by the pneumatic process to a depth of 41.8 ft. below datum, or 11.5 ft. below the dredged level in front of the quay. The caissons were rectangular, with the exception of those at the ends. Five of them were built in place in a trench on reclaimed land forming a part of the old harbor works, while the remaining nine were erected in slips and sunk in the foreshore, the depth of which varied from 3.3 to 9.84 ft.

A vertical steel shaft with an air lock at the top provided access to the working chamber of each caisson, compressed air being supplied by a battery of four duplex motor-driven compressors. The caissons were sunk with an interval of 1.64 ft. between their adjacent ends. The spaces thus left were then excavated by means of a small movable caisson, 14.43 x 7.87 ft. in plan, which was suspended by four 30-ton jack-screws placed on timber scaffolds resting on the masonry at the end of the large caissons. A groove was formed at each end of the large caissons into which the sides of the small caisson fitted. The latter was sunk to the same depth as the main caissons, or 41.8 ft. below the datum plane, and the narrow space then filled with concrete, the portable caisson being withdrawn by means of the jack-screws as successive layers of concrete were deposited, until a level of 3.2 ft. above datum was reached, above which the continuous masonry of the quay wall was finished in the open.

The new lock is 854.5 ft. long between gates and 98.5 ft. in width, the foundation over the greater part of the area covered by it being more or less compact clay, but a portion of the structure is on sand and gravel. Owing to the unequal nature of the bottom, the large quantity of water encountered and the poor foundation, the construction of the lock was handled with considerable difficulty. The gate sill is 14.75 ft. below datum, but it was necessary to carry the footing of the outer gate chamber and head wall to a depth of 55.8 and 52.5 ft. below datum, respectively. The inner gate chamber footing is at a depth of 36 ft. below that level, while the side walls are on pile foundations cut off at a depth of 24.5 ft., except at the inner end of the lock, where no piling was required.

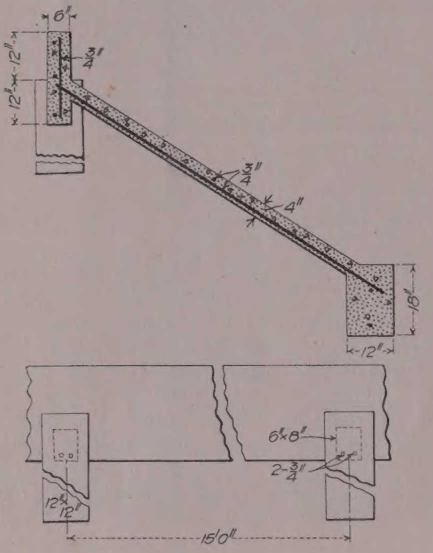
The two gate chambers were both founded on caissons sunk by the pneumatic process, the footing of each chamber being carried by a single caisson. The latter was 105 ft. wide on the center line of the lock and 213.6 ft. long across the latter. It was divided into six equal compartments by plate girders, openings being made through these girders to connect the various compartments. In both caissons the weight of the masonry is carried by the heavy girders, cross girders serving to stiffen the caisson and to prevent deformation in sinking. The junction of the lock heads with the adjoining quays and walls was made in each case by two ordinary caissons carrying return walls. The foundations of the various independent units forming the footings of the gate chambers and wing walls were made by means of a movable caisson, as in the case of the deep-water quay foundations.

The wall on one side of the lock was built on seven ordinary caissons, while the concrete and masonry for the other wall were constructed by means of a large portable caisson suspended from two steel pontoons.

THE TOWERS OF THE MANHATTAN BRIDGE in New York City were connected for the first time on June 15 by raising into place one of sixteen temporary cables that will carry two footpaths to be used in stringing the permanent cables of the bridge.

A Reservoir Slope Protection of Reinforced Concrete.

The Terry Lake Reservoir of the Larimer & Weld Reservoir Co., at Fort Collins, Colo., is formed by a long, low earth embankment that is exposed to a large amount of wave action during certain seasons of the year. This action had resulted in considerable damage to the inner slope of the embankment, notwithstanding the fact that the latter had been protected at the high-water line by riprap, so the decision was made to further protect it with a paving of reinforced concrete. During May and June, 1906, a length of 1,800 ft. of this paving was constructed as an experiment, and as the results obtained were so entirely satisfactory, the remainder of the embankment to be protected, about one mile in all, was finished in 1907. Based largely on the experience obtained in connection with this work, several other reservoir embankments exposed in a similar manner have been protected with the same type of paving.



Details of Slope Protection.

From an investigation made prior to the inception of the work done in 1906, the conclusion was reached that the face of an earth embankment, built at a slope greater than from 10 to 1, would not stand the action of the waves, and that a slope of 4 to 1, such as had been proposed in repairing the embankment, would have to have a protection of riprap or concrete. A vertical face of concrete built at the inner edge of the slope was also considered, but this would have to be constructed as a retaining wall, since the earth in front of it would work down to a 10 to 1 slope, leaving the wall to hold back the embankment. It was therefore decided to grade off and fill in the existing face of the embankment to a 1½ to 1 slope, and to lay on this slope a suitable protection of reinforced concrete; the latter running down to meet a 10 to 1 slope on the bottom of the reservoir and extending up 6 ft. above high water on the face of the embankment with a width of 10 to 25 ft. All of the foundation for the concrete below the high-water line was to be made by excavating the existing bank, thus obtaining a good solid bearing; above high water the protection was designed to rest largely on a fill, but was so detailed as to bridge over any settlement which might take place in the material beneath it. The work done in 1906 was laid about half on cut and about half on fill as had been contemplated, but the protection built during 1907 was entirely on new ground, and was laid within a week after the embankment had been deposited. All of the paving that has been completed, including that laid on the made ground, is entirely satisfactory.

The slope protection, as shown in an accompanying illustration, consists essentially of a 4-in. concrete beam reinforced with ¾-in. corrugated steel bars, spaced 2 ft. apart on centers transversely to the longitudinal center line of the embankment, and 3 ft. apart on centers parallel to that line. The reinforcement of this slab is tied into a continuous 12 x 18-in. beam extending along the toe of the embankment and into a 6 x 12-in. concrete beam along the upper edge of the slab, parallel with the one at the bottom. These two continuous longitudinal beams are tied together by transverse 6 x 8-in. beams spaced 15 ft. apart on centers and reinforced by two ¾-in. corrugated bars. The continuous beam along the upper edge of the slab is carried by concrete columns, 12 x 12-in. in cross section, the bases of which were placed at least 6 in. below the original surface of the embankment. A concrete coping, 6 in. wide at the top and 12 in. high, is also built in connection with the longitudinal beam along the upper edge of the slab.

The concrete was made in the proportions of four bags of cement to 7½ cu. ft. of sand and 15.2 cu. ft. of gravel. The gravel was in no case larger than 1½ in. in its greatest diameter, and in cases where as it came from the bank it contained a uniform quantity of sand it was used without screening, provided the proper quantity of sand or gravel was added to make the mixture the proportions required. The concrete was made wet and mushy so that it would run off a shovel if not handled quickly. The concrete on the slope was deposited from the bottom up, the coping at the top being cast in smooth forms. Before depositing materials for the new embankments, the old surface which it was proposed to cover was plowed in furrows parallel to the embankment, which were not less than 10 in. deep and not less than 18 in. nor more than 2 ft. apart. The material after being deposited in layers at least 8 in. thick was thoroughly consolidated by teaming over it and by rolling with a two-ton grooved roller. The surface of the slope to be protected with concrete was dressed fairly smooth and carried below the existing toe of the embankment until it intersected the line of a 10 to 1 slope on the bottom of the reservoir. At this intersection a 12 x 18-in. trench was excavated for the beam along the toe of the slab on the slope.

Work in Progress on the Reinforced-Concrete Slope Protection.

With cement at $2.40 per barrel the paving cost about $1.33 per square yard, exclusive of the reinforcing steel, which cost 35½ cents per square yard, delivered on the cars in Fort Collins.

The work done during 1907 was under the direct supervision and inspection of Mr. Sidney Cooper, civil engineer of Fort Collins, Mr. G. N. Houston, deputy State engineer of Colorado, acting as consulting engineer. This journal is indebted to Mr. Houston for the information from which the foregoing has been prepared.

Engineering Personality and Organization.

An address before the graduating class of Rensselaer Polytechnic Institute by Walter C. Kerr, president of Westinghouse, Church, Kerr & Co.

I have a few words to say to you about engineering individuality and organization; about the breadth of the man and of organizations; about team work; also regarding the conditions through which each man reaches his fullest capacity for the performance of his best effort; and the suggestion that you keep your eyes so wide open, and your perception so clear, that you can sense in advance the training requisite for the final attainment.

No definition of individuality, nor yet of organization, seems necessary. They possess points of similarity and of difference. The individual, whatever be his traits, is always a part of a complex organization—in fact many organizations. He is a part of human kind, of society, of a group of more or less like kind as in a profession; he is part of the organization of a nation, of a state, and probably of a municipality. At no turn can he get away from his part and companionship in organizations of many kind. He has duties to render to all. But it is not thus broadly I refer to organizations in this brief discourse. I am limiting the consideration to individualism in engineering and organization work as carried on by groups of engineers. Individualism has to do with the performance of a man himself. Organization has largely to do with what he shall perform, and what shall be the result of his performance, especially as related to cognate branches and other human effort.

An engineer should be an idealist from youth to maturity. He must aspire to high position among men. He must, through his developed capacity, grasp and control the inter-relationship of everything concerning an undertaking from conception to use. This grasp embraces the adaptation of all the varied branches of engineering to produce the ultimate results required in complex projects, and a special or expert knowledge of the predominating requirements. It should also cover a broad conception of finance, the accepted methods of procuring and accounting for funds, and a clear idea of the operation of properties after their installation.

With such an ideal clearly in mind, its attainment necessitates the appreciation that it cannot be achieved in a day, nor without long and varied practical experience. It must be sought with energy and discretion, and with earnest cultivation of breadth of view, character, integrity, healthful living, and useful recreation.

It is not given to all to realize their complete ideals, but as far as you are able to go you should make the results good.

No time can be more important or interesting to a young man than that in which he begins to apply himself usefully to his world, as he sees it. He will consciously or unconsciously shape himself to some general line of action, which will result in his becoming a certain kind of man or type of engineer, regardless of the particular operations to which his talent is applied.

We all see things somewhat differently. We are all, more or less, creatures of present influences and previous conditions. The previous condition of any man, with reference to any thing, largely shapes his view, opinion, and action concerning it.

When the man reared on the mountain and the inhabitant of the valley view the plain, their impressions are quite dissimilar. Between the man accustomed to frontier hardship and one accustomed only to the luxurious ease of metropolitan centers, there will arise divergent views concerning the common plane of average surroundings. Thus labor and capital are liable to be arrayed against each other, though their interests are really common. Many differences in the world arise mainly through divergence in view, following upon difference in previous condition.

It thus becomes easy to appreciate how men of about the same ability and influence differ in expression and action. What is often called reconciliation of views or opinions is, therefore, largely the bringing about of a similarity of mental attitude towards them. Tenacity of opinion is often only tenacity of position. Men seldom change their opinions so long as their view-point remains constant, but the broader the man the wider his angle of vision. The all-around judicial type lives on a mental plain in which he can circumscribe any problem, see it from many sides, and from his different views select the most important.

You have all grown up under quite similar conditions, and having been educated together you start into the world from about the same previous condition. You have been taught the same things that other civil engineers have learned. You have absorbed much of the conventional methods of procedure, varied perhaps with a few bold strokes of originality which surpass the conventions. You have learned more or less of the traditions of an old and honored profession, and, as is usual, you have become largely the center of your own world.

There has not as yet been much to remind you that the world is full of conditions that you have not met, of men of a type you have not known, of motives that have not been stimulated by your training, of a world full of engineering that is not static; nor have you yet met complexities and perplexities which not only require great skill and ability to handle, but which may call for combinations of human effort the realization of which has not been awakened, nor could it well be, by your previous condition.

However much you admire the achievements of the civil engineers of the past, you are more interested in correctly grasping the missions of the engineers of the future. While fundamental principles are fixed, men and methods are undergoing constant evolution.

Every young man should realize that all of the manifold organizations of which he will in one form or another become a part, are ever changing. We admit that principles never change, but it is sometimes very difficult to detect whether a so-called principle is a natural and inviolable one or merely an artificial product, especially of custom.

If there is any one thing more than another which I would say has any profound bearing upon the ability of a capable young engineer to succeed broadly in his profession, it is the correct appreciation of the relation between what he can render through his talent and that rendered by engineers of dissimilar kinds through the exercise of their talents. This underlies the relation of individual effort in team work.

Narrowness is largely singleness. Breadth is multiplicity, hence versatility. Narrowness and personal conceit are companions. Breadth and versatility lead to modesty, yet often and usually coupled with that self-confidence which makes a man a strong advocate of that which he believes.

The time was when all of the profound engineering of the world was static. The only engineer, whether called military or civilian, therefore, was the static engineer. Dynamical engineering was in its infancy, and a trade rather than a profession. The broadening field remained within the prerogative of the civil engineer, who therefore was pre-eminently the man who practiced the profession so aptly termed "the art of directing the great sources of power in Nature for the use and convenience of Man."

An expanding world with its ramifying developments caused differentiation, which led to specialization, and there became many kinds of engineers, who, in the aggregate, possessed the talents which the typical engineer should possess.

The field became too diverse for the individual man to encompass, and this led to the unwieldy, undesirable, and somewhat impractical division of labor and responsibilities which for a generation or two has existed.

The authority vested in the man, providing he exists, whose breadth and talents cover all the requirements of great diversified and complex engineering undertakings, offers a more practical means of performance than its segregation among the many.

But we must deal with men as they are, and the fact is that the necessities of great undertakings have so far outrun the individual that their performance demands a new type, an organization constructed in such a way as to combine all of the talents and restrict the limitations of the many, which shall exercise the necessary judgment and control.

All engineering operations are carried on through organization. The differences lie only in degree. The engineer with one man to help him is the simplest form. When an engineering corps is organized, the degree is raised. A large corps becomes complex and needs management, and when it grows so large as to be divided into squads containing men of different talent undertaking unlike work, real organization methods have been adopted. When this is further extended and made permanent for doing diverse things for many people, instead of forming for an undertaking and disbanding when through, we have the type of permanent organization which may be called the new engineer.

The creation of this new type of engineer is the latest phase of engineering development. It is rather less than a quarter of a century old, and in high effectiveness perhaps not more than a dozen years.

This new type is the engineering organization, not merely an aggregation of man, but a real organization; organized slowly, just as men grow; correlated slowly, just as men become educated; made effective by long processes of joint action and joint experience; rounded to a degree scarcely possessed by any individual man, through the abrasion by contact of personalities differing sufficiently to shape each other, yet not enough to create friction.

This process has now been continued until there exist a number of such engineering organizations, in the ranks of which are found civil, mechanical, electrical, and hydraulic engineers; also those versed in the special arts, such as lighting, heating, ventilating, machine tools, and compressed air. With these are associated men equally versed in thermodynamics, chemistry, statistics, architecture, law, and commercial affairs. Such organizations naturally also have the contingent following of draftsmen and assistants of all required kinds and talents.

Such an organization, even when composed of hundreds of individuals, acts—under proper management—virtually as one man. Its capacity obviously becomes great. On a given project, the various divisions can be worked up in parallel—it being the mission of some to see that the different kinds of work are constantly correlated, and that when the work has developed to a certain stage there are provided numberless hands and feet to attend to its performance.

This is one phase of the modern engineer which has grown, unconsciously, by force of necessity rather than by specific intent. It has the capacity to create a property from inception to operative finish. It is always ready at a moment's notice to undertake work of any kind and magnitude. It is always available for emergencies. It has grown in response to the demands of complex physical properties, which need to be created as a whole—with equal skill devoted to all their widely differing function, and which are too intimately related to be served by men whose work is not correlated by organization.

Financiers and others who must carry the prime responsibility for the creation of the largest works desire to lean on the fewest individuals, and as the complexity of their work would demand many personalities they naturally seek firmly developed organizations which so combine these personalities that they can lean on the group as on a man.

It is frequently remarked that large work, costing millions of dollars and extending over a period of years, suffers a needless hazard when entrusted to an individual, who might die, or be incapacitated by severe illness, or even possibly become mentally less competent as the work progresses. From these limitations, organization is the safeguard.

Such organizations in general comply with the usual conventions and practice of the respective types of engineers employed. They contain ample demonstration of the strength of unity.

Parallel with the growth of such organizations, there has been another development which might seem contrary to precedent, but which on closer analysis will be found to be rather a return to first principles. It is the performance by such organizations of constructive work, this being performed for a fee in the unselfish spirit of engineering service, and not in the speculative or selfish spirit of contracting.

In the recent past, it became usual for engineering work to be designed by the highest talent, but executed through common and almost unskilled labor. Further development has constantly necessitated higher grades of skill in performance, and a closer supervisory conduct of the work by the engineer. This process continued until the time came when much of the performance of the work was of exactly like kind with its design, and in order to get it correctly performed the engineer needed to put his hand to the work itself. This began chiefly in dynamic lines, and has extended to others.

I think the time has about arrived to conceive of engineering as beginning with contemplation and passing through design and specification to and through construction and placing in operation, with no change of hands and with no break in the continuity of direct engineering control of the work itself.

This view one often hears unconsciously voiced by an engineer who, after all kinds of trouble and excess costs through contractors, says: "Give me workmen with a few foremen and superintendents and I will do the work myself and do it right, on time, and within the estimates."

One of the Stevensons of Edinburgh, a family famous in engineering work for more than a century, said: "The duty of the engineer is twofold—to design the work, and to see the work done."

There have been too many artificial divisions as to where one type of effort should stop and another begin. A principal one of late generations has been the line between design and construction. This is not a natural division, but a purely artificial one, born perhaps of the practice of meeting the conventional views of a given time. Times change, however, practice varies, and it becomes easy to see that what may have appeared like natural divisions are after all only artificial.

A parallel to this lies in what we call the natural orders of plants. We are taught in botany to regard these natural orders as divided from each other by natural lines, and we therefore refer to the natural divisions. A moment's reflection, however, will indicate that there is simply a natural sequence from the lowest to the highest, in which man has drawn artificial lines for convenience of classification, and thereby divided from each other certain orders which possess more or less like characteristics. It is the sequence which is natural and not the orders. So in engineering, from inception through to finished construction, there is a natural sequence to performance, rather than natural dividing lines. Keep your eye on integration, rather than differentiation.

The burden is upon every engineer to do his work right, not merely to design it right and let some one else do it wrong. He may utilize any means of assistance, by contractors or otherwise, but if through such assistance he cannot get proper results, he must be able and willing to put his own hand to the work and bear his burden. The frequency with which assistance fails leads many by experience to do their work at first hands, and organizations of engineers largely follow this method in the interest of quality, economy, and time.

The importance of this to the young man is that with each passing generation a considerable change has taken place in all modes of procedure, and it is not to his advantage to find that methods have changed while he is asleep. He should be alert to see what changes are coming and judiciously meet those which are real.

I use this development of the engineering organization as illustrative of a change that has come, and it is indicative of others. Among these may be briefly mentioned the fact that the individual engineer, as he becomes broader, is becoming more of a factor in affairs. His advice is sought in things other than engineering, yet more or less related. He is constantly growing more into the counsels of men of other vocations, and will stay there just in proportion to the degree in which he is helpful.

A corroborating feature in the quality of this development is the cycle through which it returns to the simplicity of first conditions. Early architects designed and constructed. Early engineers designed and constructed. Both grew with the advancing arts. Differentiation occurred. Professionalism arose. The professional man ceased to construct. Further advance caused professional specialization. Creative forces scattered from the man to the many. Organization has brought together these personalities and, through well-ordered means, returned in effect to the individual. The individual, then, through this effective organization, constructs, and we are back again to the early days in which the architect and the engineer both designed and constructed.

It was Emerson who called attention to the difficulty of stating one truth without violating some other. It is thus difficult to discuss the qualities of organization without giving rise to some misapprehension.

I especially do not wish to imply that organization displaces or absorbs personality. Let no man fear that in entering an organization he is sacrificing his individuality. Individuality is not limited by organization, but the means of individual expression become changed. A man cannot be a bad man and a good engineer. He may think he can, but he cannot. A man will find his level, be it high or low, more quickly in organizations than elsewhere. His qualities and limitations become better and more quickly measured.

The necessity for the development of engineering organization does not mean that the day of the single-handed engineer is over, though it must be admitted that the years as they pass are constantly surrounding him with additional limitations. There are men who are better fitted for individual effort than for what is generally called organization work. There is also a great field for their effort. It is fortunate that all men are not alike, and that all work has not the same characteristics and requirements. With the immense growth of material things, there has become such a diversity of operations that there is room for every type of man, every kind of temperament, and every form of good organization.

Each man needs to perceive where he fits best, and to follow that in which his experience, and perhaps his opportunity, indicates the greatest hope of achievement, but nothing can be worse than for a man to fail to realize that there are many paths, some similar, others widely unlike; that there is room for all; that all work to a common end; that some ways are better than others for achieving certain types of excellence; and that the inferior result in mediocrity or failure. Many a man has made a signal success of his life working single-handed. Others who would have thus failed have done creditably well in organizations where their best talent could be conserved, their weakness supplemented, and their limitations safeguarded.

The high specialization necessary for great profundity in any one branch of engineering tends to limit the capacity of the individual in the practical conduct of work, but not so when he exercises his effort through an engineering organization. For this reason, I believe the ablest engineers, to accomplish their ambitions most surely within the comparatively few years alloted to a man to work at his best, will prefer to identify themselves with organizations which carry, without their individual effort, the major burdens of physical operations, so that their portion of profoundly skilled service can be rendered into the largest volume of work.

There is much difference between things and the names of things. Thus organization is to many a name, but if any one will spend a quarter of a century developing an organization they will find that the name can be forgotten, except for convenient use, and their thought will turn to what it means to perfect an organization and make it effective. It is not sufficient merely to bring talented men together. Men who are individually effective are often ineffective when grouped. Talent alone is not sufficient, but temperament and personality are factors of the utmost importance in the necessary correlation of team work.

The relations of engineers with each other and of engineering organizations should be non-competitive. The word "competition" is too much used. It has a wrong ring. Engineers, like educational institutions, should each wish to excel, but not to the detriment of others. Thus they should treat with each other in the spirit of helpfulness, discarding all spirit of rivalry and jealousy. This not only conduces to the welfare of all and to the good of their work, but its free exhibit is inspiring to clients.

I am glad to see that this institution is broadening its scope to include other engineering besides that which it has taught longer than any other institution in this country. The reason this was done is that the day has come for it, and with the time there always comes the man to lead it. The day has quite passed for the classification of the different kinds of engineering, and keeping them apart as segregated world's functions. The growth of innumerable arts and the breadth of their application have produced a complexity which cannot be unraveled in the name of any one type of engineering performance.

A man studying one branch of engineering can acquire much knowledge of other branches through contact. This contact requires the presence of men and facilities, a broader world, in which a man principally acquires that for which he strives, but also much that is useful which rubs off against him. There is no influence so good, even if it had never been done before, but somewhat or widely different. All this would be good, even if it had never been done before, but now, in the light of the world's demands, it is imperative, and the broader engineer will result.

Some men have apparently great discernment for seeing about half way through things. In nothing more than in engineering is it necessary to see all the way through. This capacity is not altogether a matter of age and experience. It is born in some and cultivated in others. To see all the way through requires contact with all that is to be discerned.

Ability to cerebrate has not materially increased in the past two thousand years, but ability to get facts has. This marks the difference between logic founded on the intellect and that based on laws, facts, and real knowledge. The engineer starts from the latter, and if he will safeguard his facts his logic will not go far wrong. In one sense it may be said that a man's horizon extends as far as he can see, while his radius extends only as far as he can act. You need to broaden the one and lengthen the other.

Every young man should realize that the way about which he has been thinking may be outclassed by a way that has not occurred to him, and should keep an open, wholesome, and receptive mind regarding all relationships in the world and all methods of performance, with a discerning eye to the advancement of method as the world passes from decade to decade, and to read the handwriting on the wall just a little before it is written.

Whatever exertion you may be willing to make to use your knowledge in the rendering of your engineering skill, do not forget to use your personality. This counts for much. You may not be conscious that you use it at all. You cannot prevent its use, for your personality will surely make its impression upon every one with whom you come in contact. If it is not the kind you particularly approve, change it all you can. If it is the kind that others do not seem to approve, it is your particular duty to suppress some of it and shape the balance.

Let every young man, therefore, with his strongest personality, his best personal effort, and with great confidence in his own resources, co-operatively join hands with his fellow-engineers and fellow-men in whatever manner seems, from time to time, to best render the service needed, and this will be most effectively accomplished when performed in the spirit exemplified by Abraham Lincoln, who, in his great breadth of wisdom, said: "You may do what you please with me so long as it is for the good of the cause."

Defective Surface Drainage due to street improvements were recently the cause of an action before the Indiana Appellate Court, 84 N. E. Rep. 519, in which it was ruled that a town collecting surface waters in a channel along the street and then obstructing the channel, thereby causing the water to flow on adjacent property, is liable for the injuries sustained. More specifically, the court ruled that the damming of a gutter along a street by an embankment, without providing egress for the surface water that anyone knew would collect, is negligence, rendering the municipality constructing the embankment liable for injuries to adjacent property caused by water overflowing it.

The Design of Retaining Walls.—II.

By Harold A. Petterson, Office Engineer, Los Angeles Aqueduct, Los Angeles, Cal.

Reinforced Concrete Retaining Walls.—The only type of reinforced concrete wall which will be taken up the present time is the counterfort type shown in Fig. 4. This type of wall is often designed with either no projecting toe, or else with a small projection which bears no relation to the total width of base. For a given width b the writer would make the width of the projecting toe $= 1/3b$ where $b =$ total width CB. This is the economical projection for the toe on the assumption that the intensity of foundation pressure varies from a minimum at the heel B, to a maximum at the toe C. This is proved as follows:

Let M_r represent the resisting moment as previously defined. Let the weight of superincumbent earth and wall be represented by W_1. The center of moments is at E, distant $1/3b$ from C.

Let l represent the width of superincumbent earth and wall, whose height is h.

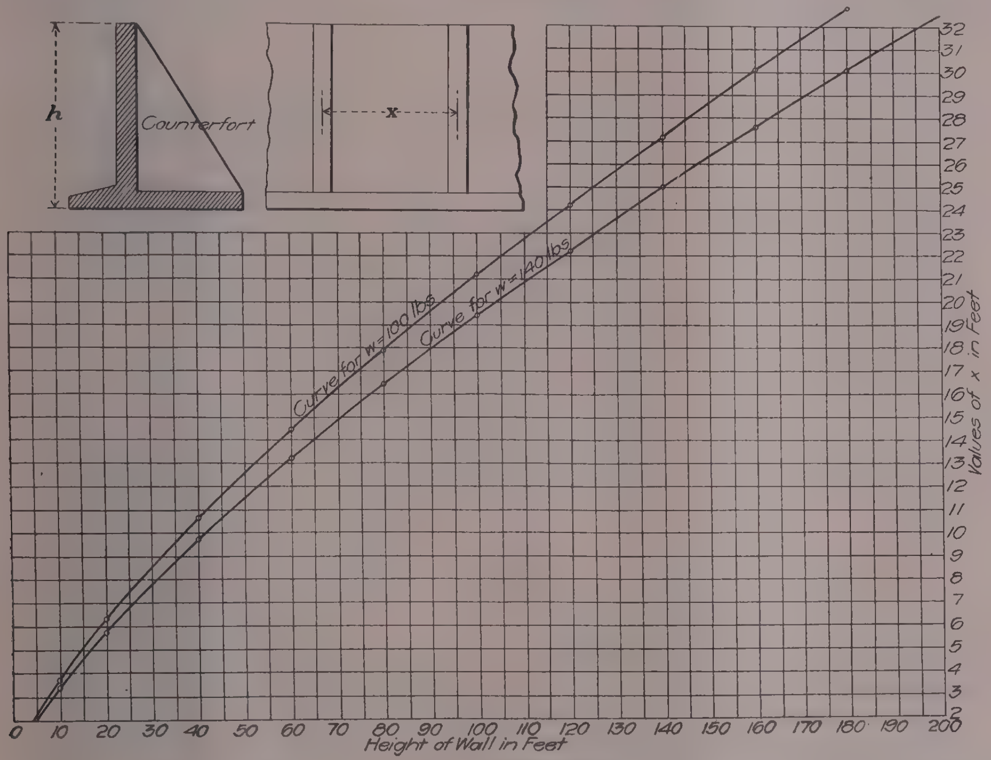


Diagram 1.—Economic Spacing of Counterforts for Heights up to 200 Feet.

Then $W_1 = hlw$.

If l is less than $2/3b$, the lever arm of W_1 equals

$$\tfrac{1}{2}l + (2/3b - l) = (4b - 3l) \div 6.$$

If l is greater than $2/3b$, the lever arm of W_1 equals

$$\tfrac{1}{2}l - (l - 2/3b) = (4b - 3l) \div 6.$$

Hence $M_r = W_1(4b - 3l) \div 6$.

But $W_1 = hlw$ or $M_r = (4b - 3l)\,hlw/6 = 2/3\,hlwb - \tfrac{1}{2}\,hwl^2$

Differentiating M_r with respect to l, we have

$$\frac{d\,(M_r)}{d\,l} = 2/3\,hw\,b - hlw = 0, \text{ or } l = 2/3b.$$

To determine the required base width, b, for the type of wall shown in figure 4. The overturning moment M_t, as in the three cases of the gravity wall, is awh^3. The resistance to overturning is furnished by the weight of the earth backing and the weight of wall and base slabs. Since the thicknesses of these slabs are small in comparison with the width b, the weight of these slabs is assumed equal to the same volume of earth. The resulting error is small and on the side of safety. The weight resisting overturning is then $W_1 = 2/3\,bhw$. The lever arm of W_1 is b/3 and

$M_r = 2/9\,b^2hw$.

$M_r = M_t$ or $awh^3 = 2/9\,b^2hw$, or

$$b^2 = 9/2\,ah^2 \text{ or } b = h\sqrt{4.5a}. \qquad (6)$$

Hence b is independent of the weight w. Table 5 contains the required values of b to insure stability for this type of wall.

TABLE 5.—WIDTH OF BASE FOR WALL WITH COUNTERFORTS

Angle of Repose.			Required width b.
Slope.	Deg.	Min.	
¼–1	75°	58′	0.107 h.
½–1	63°	26′	0.204 h.
1–1	45°	00′	0.358 h.
2–1	26°	34′	0.535 h.
3–1	18°	26′	0.625 h.

Economic Spacing of Ribs.—After determining the width b, the next step is to determine the spacing of the ribs or counterforts.

In figure 5, let X equal the distance from center to center of counterforts. By the use of the differential calculus, the writer has found that the value of X varies with $h^{\frac{3}{4}}$, or expressed in a formula,

$$X = qh^{\frac{3}{4}} \qquad (7)$$

Diagram 1 is based upon (7). From this diagram the value of X can be taken for any height of wall up to 200 ft. The formula is developed at the end of this article.

Retaining Wall Design.—Before commencing on the design of a retaining wall the following quantities must be determined:

1. The height of the wall, h.
2. The angle of repose of the earth, ϕ.
3. The unit weight of the earth, w.

The next steps are:

4. Determination of the width of base, b. This width can be taken from table 5.

5. Spacing of ribs, X. Values of X are taken from diagram 1.

6. Thickness of toe slab at E. (Fig. 4.) This toe slab acts as a cantilever of length $1/3b$. The forces acting upon this cantilever are: (a) The weight of slab itself acting downward, which can be neglected. (b) The upward forces of the foundation reaction.

These forces vary from a maximum p at C to a value $2/3\,p$ at E.

$$\text{The total force} = (p + 2/3p)\,b/6 = 5/18pb = R_1 \qquad (8)$$

$\tfrac{1}{2}\,pb = W_1$ where $W_1 =$ total weight of superincumbent earth, $W_1 = 2/3bhw$ or, $p = 4/3\,hw$ or (8) becomes $R_1 = 10\,hbw \div 27$.

The lever arm of R is found to be $8/15$ of $b/3$.

$$\text{The bending moment} = 8\ R_1b/45 = 16\,hb^2w \div 243 \qquad (9)$$

(9) gives the bending moment in foot pounds when h and b are expressed in feet, and w is in pounds per cubic foot.

7. Thickness of base slab EB. (Fig. 4.)

The effective span $= X$, and can be taken from diagram 1. The forces acting are the weight of the earth, of depth h acting downward, and the foundation pressure from B to E acting upward.

The forces acting downward $= hw$ pounds per square foot, as shown graphically in (a) Fig. 6. The upward forces vary from 0 at B to $8/9\,hw$ at E, as shown graphically in (b) Fig. 6. The resultant of these two sets of forces is shown in (c) Fig. 6. We thus see the loading varies from hw pounds per square foot at the heel of the slab to $1/9\,hw$ pounds per square foot under the wall.

Theoretically the ratio of slab depths at B and E would be as the $\sqrt{9/1}$ or 3 to 1. The writer would recommend, however, that the slab be made of uniform depth equal to that required at B. To determine this depth, we consider a portion of slab of unit width. The loading $= hw$ pounds per square foot. The span $= X$ feet, or the total load $= hwX$ pounds $= P_1$. The slab may be considered a continuous beam fixed at the counterforts. In that case the bending moment $= P_1X/24$ foot pounds at the center of the span and $-P_1X/12$ foot pounds at the counterforts. However, a more conservative design will result, if the value of the bending moment be taken as $P_1X/10$ at both the center of span and at the counterforts. We then have the following value of the bending moment:

$$\text{Bending moment} = P_1X/10 = hwX^2/10 \qquad (10)$$

8. Thickness of wall slab.

The forces acting against the wall slab are the horizontal components of the earth pressure. Call the intensity of pressure t which varies from a maximum at the base of the wall to a minimum at the top. The maximum value of t at the base is found as follows:

$$t\,h/2 = H, \text{ or } t = 2H/h$$

Values of H are given in table 1, and may be expressed as

$$H = \lambda wh^2$$

or

$$t = 2\lambda wh^2/h = 2\lambda wh.$$

The total load for span $X = tX = 2\lambda whx = P_2$

The bending moment may again be taken as

$$P_2X/10 \text{ or } \lambda whx^2/5 \qquad (11)$$

Having given the values of the bending moments for the base, wall slabs and the cantilever toe, the thickness of the concrete and the area of steel reinforcement can readily be determined by using slab and beam tables and diagrams previously prepared.

Economic Spacing of Ribs.—Let $X =$ the distance, center to center of ribs in feet; $d_1 =$ the average thickness of the concrete in the wall slab in feet; $d_2 =$ the average thickness of the concrete in the base slab in feet; $d_3 =$ the average thickness of the concrete in the ribs in feet.

To determine the economic spacing of the ribs we determine the volume of concrete per lineal foot of wall. The value of X which makes this volume a minimum is the economic spacing which we are seeking. The thickness of the projecting toe is independent of the rib spacing, and will not need to be considered. The volumes in cubic feet per lineal foot, of wall slab, base slab, and ribs, respectively, are as follows:

Volume of wall slab $= hd$ (12)
" " base " $= 2/3bd_2$ (13)
" " ribs $= bhd_3 \div 3X$ (14)

Equation (14) is based on the assumption that the thickness of the rib $= d_3 = h/20$. This ratio agrees fairly well with existing practice, and is believed to be amply large.

To determine the values of d_1 and d_2 with respect to h and X. From the concrete formula $M = K b_1 d^2$, or for the unit width of beam $M = K d^2$. Moreover $M = P_1 X^2 \div 10$ for a uniformly loaded beam, where P_1 represents the loading per lineal foot of beam. For the base slab, from (10),

$$P_1 = hw \text{ or } M = hwX^2 \div 10$$

For the wall slab, from (11)

$$M = \lambda whX^2 \div 5$$

Hence for the wall slab, we have

$$Kd_1^2 = \lambda whx^2/5 \text{ or } d_1^2 = \lambda w\,hx^2 \div 5K$$

$$d_1 = a_1 X \sqrt{h} \qquad (15)$$

where a_1 is a constant for any given case.

For the base slab,

$$Kd_2^2 = hwX^2 \div 10$$

$$d_2 = a_2 X \sqrt{h} \qquad (16)$$

where a_2 is a constant for any given case.

From table 5, b is also a function of h $= \beta h$.

If we substitute these values of d_1, d_2, d_3, and b in equations 12, 13 and 14, we have the volumes per lineal foot as follows:

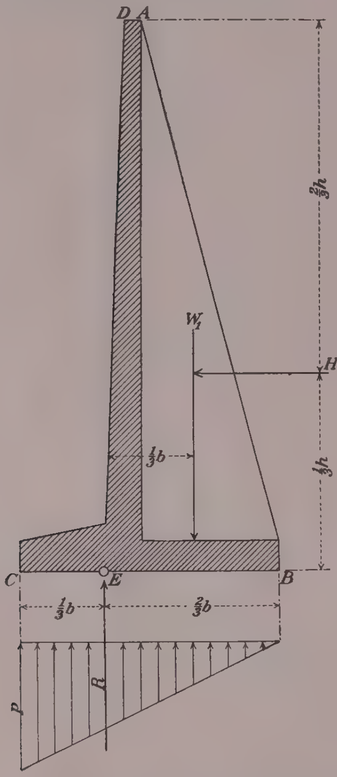


Fig. 4. Reinforced Concrete Counterfort Wall.

$$\text{Vol. wall slab} = hd_1 = a_1 X h^{\frac{3}{2}}. \qquad (17)$$

$$\text{“ base “} = 2/3\, bd_2 = 2/3 \beta h a_2 X \sqrt{h}$$

$$= 2/3 a_2 \beta X h^{\frac{3}{2}} \qquad (18)$$

TABLE 6.

Angle of Repose.			Value of a_1.			Values of a_2.		
Slope.	Deg.	Min.	$w=100$	$w=120$	$w=140$	$w=100$	$w=120$	$w=140$
¼–1	75°	58′	0.00221	0.00242	0.00262	0.0300	0.03285	0.355
½–1	63°	26′	0.00352	0.00386	0.00416	"	"	"
1–1	45°	00′	0.00622	0.00681	0.00736	"	"	"
2–1	26°	34′	0.00927	0.01016	0.01097	"	"	"
3–1	18°	26′	0.01080	0.01182	0.01278	"	"	"

$$\text{Vol. rib} = bhd_3 \div 3X = \beta h^3 \div 60X$$

Let the sum of these three volumes be represented by V

$$V = a_1 X h^{\frac{3}{2}} + 2/3 a_2 \beta X h^{\frac{3}{2}} + (\beta h^3 \div 60X)$$

The minimum value of V will result, when the first derivative of V with respect to X equals zero, or

$$\frac{dV}{dX} = 0 = a_1 h^{\frac{3}{2}} + 2/3\, a_2 \beta h^{\frac{3}{2}} - (\beta h^3 \div 60X^2)$$

$$\text{or} \qquad 60\, X^2 h^{\frac{3}{2}} \;(a_1 + 2/3\, a_2 \beta) = \beta h^3$$

$$\text{or} \qquad X^2 = \frac{\beta h^{\frac{3}{2}}}{60a_1 + 40a_2\beta}$$

$$\text{or} \qquad X = h^{\frac{3}{4}} \sqrt{\frac{\beta}{60a_1 + 40a_2\beta}}$$

From (7) $X = qh^{\frac{3}{4}}$ where $q = \sqrt{\dfrac{\beta}{60a_1 + 40a_2\beta}}$

From (15) $a_1 = d_1 \div X\sqrt{h} = d_1 \div 12X\sqrt{h}$ when X and h are in feet and d_1 is expressed in inches.

Similarly from (16) $a_2 = d_2 \div 12X\sqrt{h}$ when d_2 is in inches.

To determine a_1 and a_2 the writer designed several walls of different heights, and determined the actual thicknesses of wall and base slabs required. The following unit values were used in this design:

$C = 500$ lb. per square inch = value of concrete in compression.

$S = 14{,}000$ lb. per square inch = value of steel in tension.

$E_s/E_c = 15$ and $K = 77$.

$M = Kb_1d^2$.

The formulas used are those of Taylor and Thompson. The resulting values of a_1 and a_2 were found to be independent of the height, h, and the rib spacing, X.

The values of a_1 were found, however, to vary with the angle of repose, ϕ, and with the square root of w, the unit weight of the superincumbent earth. The values of a_2 were found to be independent of the angle of repose, ϕ, but also varied with the square root of w.

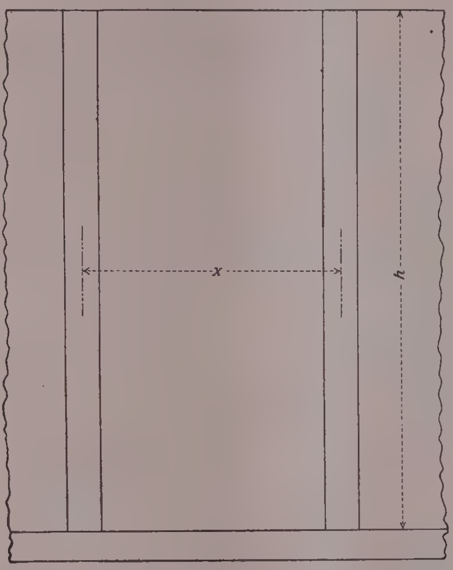


Fig. 5. Reinforced Concrete Counterfort Wall.

Table 6 contains these values of a_1 and a_2. By substituting in (7) the values of β from table 5 and the corresponding values of a_1 and a_2 from table 6, we obtain the values of q. These values of q are independent of the angle of repose, but depend on the unit weight of the superincumbent earth. The value of q is 0.67 for $w =$ 100 lb.; 0.64 for $w = 120$ lb.; and 0.615 for $w =$ 140 lb.

FACE STONES for the Pathfinder dam, amounting to 5,567 sq. ft., were quarried and cut at a labor cost of 0.91 cents per square foot and a supply cost of 0.16 cents per square foot, according to the "Reclamation Record." The stone was a hard, coarse-grained granite and extended about 3 ft. into the dam, making the total cost per cubic yard $9.63. These figures do not include plant charges and the cost of steel, oil and coal for the forges.

Waterways of New Jersey.

Abstract of an address by Hon. John Franklin Fort, Governor of New Jersey, before the Conference on the Conservation of Natural Resources at Washington.

The progress of our nation depends upon its commerce. It is recognized universally that the germinal principle of commerce is transportation. I believe the most important problem which confronts us as a nation is the efficient and economical distribution of our products, both natural and manufactured, in the correct solution of which is involved not only our immediate prosperity, but our future well-being and national greatness.

Railroad construction has been overtaken by the development of our industries, and the nation as a whole has suffered, by reason of the inability of our railroads to keep step with our rapid industrial growth. Measured in ton-miles, freight traffic in this country has increased over 400 per cent. in twenty years, and of the total estimated wealth of the country, railroad freight charges amount to the stupendous figure of 1½ per cent. It is apparent to every student of the times that additional facilities for transportation must be provided if we are to maintain our commercial supremacy.

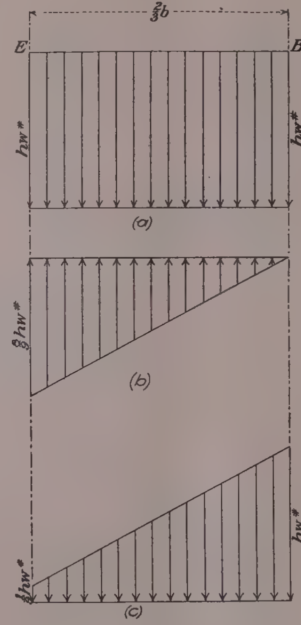


Fig. 6. Forces at Base.

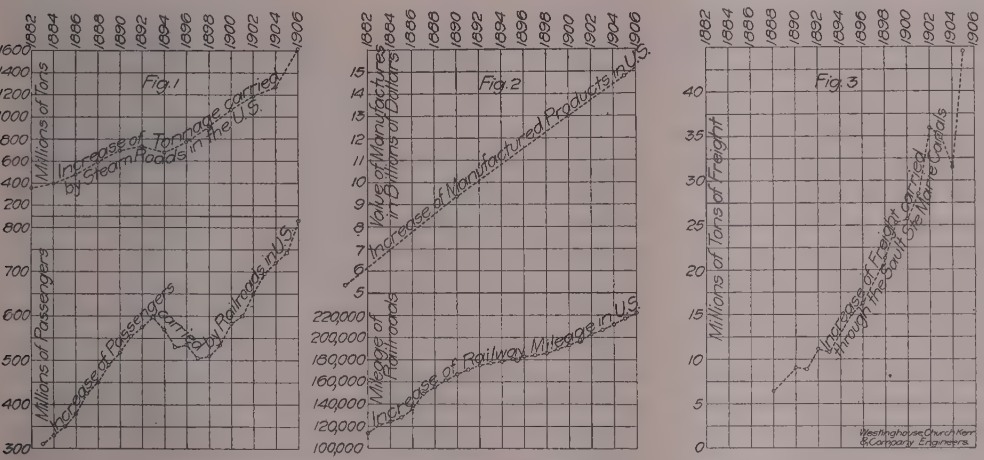
These facts can be well illustrated graphically. Figure 1 shows to scale in millions of tons the tonnage carried by steam roads in the United States each year from 1882 to 1906, also in millions of passengers carried during the same period. Figure 2 shows in billions of dollars the increase in value of manufactured products in the United States for each year from 1882 to 1906, and immediately below the mileage of steam railroads in the United States for the same period. Figure 3 shows in millions of tons the freight passing annually the Sault Ste. Marie canals from 1888 to 1905, which illustrates what one single canal improvement has accomplished.

Hon. James J. Hill states that our railroads are inadequate to meet the demands made on them. From Mr. Hill's expressed views Governor Fort holds it is apparent that we cannot anticipate immediate relief from the railroads and must look elsewhere for a remedy. Overlooked for years, save by the sagacity of the few to whom we owe the creation of the Inland Waterways Commission, it is recognized that in the great primal scope of things our waterways were meant to serve as highways for our commerce and to provide inter-state communication.

An examination of every map of the United States will reveal that navigable rivers and lakes traverse our land from the East to the West and the North to the South. No nation the world over can boast of such an abundance of natural waterways. The development of the waterways of the country is one of the most commendable projects undertaken by the national government and one which will materially add to the commercial advancement of our country.

The marvelous growth of our country has been made possible solely through the energy of the men whose skill has consummated the greatest railway systems ever known to the world, to whom we must rightfully attribute much of our material success. It is but natural to assume that in extending the railway enterprises of our land many mistakes have been made; on the other hand, it would be supernatural if errors had not ensued.

For the past thirty or forty years most of the brains and skill of our brightest men, together with their capital, has been invested in the creation of utilities for public service; first, in the construction of extensive steam railway lines; second, in the creation of street railway projects, and, third, in the development of water powers for the production of heat, light and power. So much has this been so that, with few exceptions, the American nation has lost sight of the importance of its waterways.



Various Comparisons of Traffic Conditions in the United States.

Governor Fort strongly advocates the rehabilitation and utilization at moderate expenditure of such of our artificial waterways as are not beyond redemption. This would afford immediate relief to our facilities of transportation and would involve but nominal expenditures. He believes this work should be undertaken as expeditiously as possible and that the executives of the several states in which these artificial waterways are maintained should lend their energies and their influence in this behalf. And, further, that it would be advisable that each state create by legislative enactment a waterways commission, composed of engineers of recognized ability and public-spirited men of large affairs, to carefully investigate the conditions and necessities of each state, to make the necessary recommendations and outline a concrete plan to be followed by each state within its borders, or by the Federal Government, as may be decided upon after due consideration of the legal questions involved and the determination of the status of all the parties at interest in this important matter. Governor Fort is likewise of the conviction that ultimately every means of transportation of our railways and our waterways will be co-ordinated, and believes that any plans evolved should have the eventual co-ordination of transportation facilities in view.

The remainder of the address was confined to a consideration of water transportation and forestry as regards New Jersey, and from the discussion of the former subject the following notes have been made: New Jersey occupies a strategic geographical position with reference to the New England, Southern and Mid-Western States. Situated between Philadelphia and New York City, its southwestern shores form a part of the Philadelphia harbor, while its northern shores form a part of the New York harbor, and it also lies between the great anthracite coal mines, the iron and cement fields of the Lehigh Valley, and tide water. With its Hudson and Delaware Rivers and Newark and Raritan Bays, it furnishes safe and protected anchorage for vast fleets of vessels, and from these bays barges could pass through its rivers and inland natural and artificial waterways to every important city of the state.

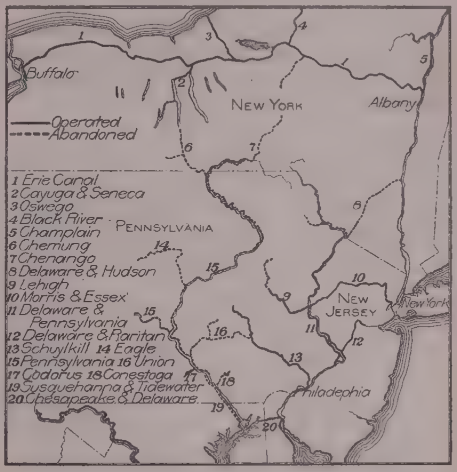
Through the use of its own waterways and canals, in connection with the Lehigh Canal, which lies in Pennsylvania along the western shores of the Delaware River, New Jersey is the gateway to tidal water for the anthracite coal fields; and transportation by water is practicable in conjunction with the Delaware River and the Chesapeake and Delaware Canal for the bituminous coal of the West Virginia fields to all its manufacturing cities. With these water facilities made available, water transportation to all its manufacturing cities and the tide-water becomes open to the great cement fields and pig iron of the Lehigh Valley, and to the incoming iron ore from Cuba and the Northwest, lumber from the South, clay and all heavy bulk material used for manufacturing and building purposes within the state. In like manner its natural and manufactured products can be shipped to tide-water, from whence they can be distributed to the whole Atlantic Coast and by the Hudson River and Erie Canal to the lake regions and the Northwest.

An inspection of the accompanying map, which shows the canal systems leading in all directions from the anthracite coal fields, shown by cross hatching, and across the state of New Jersey to tide-water, will clearly illustrate New Jersey's position. The total production of anthracite coal from the Pennsylvania coal fields in 1906 was approximately 71,000,000 tons, valued at $132,000,000 at the mines. Of this amount over 62,500,000 tons were shipped from the anthracite fields. The principal railroads over which this coal passed are as follows, the figures being gross tonnage: Philadelphia & Reading Ry., 18,241,512; Lehigh Valley R. R., 9,971,699; Delaware, Lackawanna & Western R. R., 9,201,875; Erie R. R., 5,636,537; Delaware & Hudson Co., 5,346,695; Pennsylvania R. R., 4,856,004; New York, Ontario & Western Ry., 2,444,273.

The total exports of the United States of anthracite coal were 2,216,969 gross tons, valued at over $10,800,000. The amount of anthracite coal shipped to the port of New York, which includes the Jersey shore as well, and re-shipped from that port was 12,739,518 tons, while the anthracite shipments to Philadelphia were 5,622,137 tons, and to Baltimore 707,425 gross tons. This tends to show the heavy movement of anthracite coal from the coal fields to the seaports and indicates the movement of this commodity across the state of New Jersey.

No records are available showing the anthracite coal consumption in New York City and surrounding communities, but estimates by men of long experience in the coal trade place this consumption at from 15 to 25 per cent. of the total anthracite output. The greater part of the coal re-shipped from the port of New York goes by coal barge or sailing vessel, and in the absence of a continuous inland waterway paralleling the coast there have been many and serious losses of these coal carrying vessels, especially among the barges. One of the great advantages in the shipment of coal in barges by canal from the fields will be the saving in rehandling of coal, as with the completed scheme of inland waterways this coal can go directly in the original bottoms to ports on the New England and Southern coasts as well as the port of New York.

The cement manufacturers in the Lehigh Valley, which occupies practically the same position with relation to New Jersey as the anthracite coal fields, produce annually almost one-half of the Portland cement manufactured in the United States, the total production in the United States in 1906 being 46,463,000 barrels, of which 22,784,000 barrels were made in the Lehigh Valley. The average value of the cement manufactured in the Lehigh district for 1906 was $1 per barrel, or a total of $22,784,000. This immense tonnage is tributary to the railroads and canal systems crossing the state of New Jersey and would find its natural Eastern outlet through the ports of New York and Philadelphia. The important part which cement plays in almost all types of building construction to-day makes the cheap transportation of cement a matter of vital importance to the whole country.



Canals of New Jersey and Vicinity.

New Jersey is pre-eminently a manufacturing state and in many industries leads the nation, notably in the silk industry and in the smelting and refining of copper, in both of which New Jersey ranks first. It holds second rank in the production of pottery, terra cotta and fire-clay products, and fourth rank in the jewelry and glass industries. Other large industries are slaughtering and meat packing, chemicals, electrical machinery, foundry and machine-shop products, leather tanning and finishing, malt liquors, bread and other bakery products and petroleum refining.

The total number of manufacturing establishments in the state in 1905 was 7,010, representing an invested capital of $715,060,174, employing an average of 266,336 wage-earners and using raw materials to the amount of $470,449,176, from which are produced finished products valued at $774,369,025. These establishments have installed and in use a total of about one-half million horse-power, of which over 78 per cent. is steam power.

The extent and condition of the waterways of New Jersey, intercoastal and inland, natural and artificial, is briefly summarized in the following statement: New Jersey has an outer coastline water frontage of 260 miles and possesses acres of harbor anchorages where vessels of the deepest draft may float. It also has 119 miles of navigable rivers and 172 miles of canals. None of the latter have been actually destroyed, but all are in the possession of private corporate interests. New Jersey is served by the Hudson, Passaic, Hackensack, Raritan, Arthur Kull and Delaware rivers, and by the Delaware and Raritan and Morris and Essex canals; supplemented by the Lehigh Canal, which, though situated in Pennsylvania, also operates to serve the state.

The mean depth of the rivers and bays is as follows: Raritan River, from New Brunswick to Raritan Bay, 19½ ft.; Raritan Bay (channel), 21 ft.; Arthur Kull, 19½ ft.; Kill Von Kull, 26 ft.; Newark Bay, 6½ to 33 ft.; Passaic River, from Newark Bay to Newark, 9 ft.; Hackensack River, from Newark Bay to Hackensack, 11 ft.

The canals which have been enumerated were primarily built to serve the anthracite coal trade and upon which their prosperity was dependent. However, with their control vested in corporate railroad interests, they have practically passed into disuse.

The most important of these artificial waterways is the Delaware and Raritan Canal, which Governor Fort believes offers the best route for the proposed Atlantic Coast intercoastal waterways development. Connecting the Amboys on the east, with Bordentown on the west, and serving the industrial cities of Trenton and New Brunswick, it affords an efficient and economical channel for commerce passing between the ports of New York and Philadelphia. This canal from 1867 to 1874 carried an annual tonnage of over 2,000,000. It was acquired by the Pennsylvania Railroad in 1871, under lease at an annual rental of 10 per cent. upon its cost, which amounts to $584,740 per annum. By reason of the high tolls charged and diverting freight from the canal under railroad control, the tonnage has decreased, so that at the present time it has fallen to an insignificant amount, not in any wise sufficient to pay its operating expenses, to say nothing of meeting its annual fixed charges. With proper engineering determinations, followed by sufficient improvement and development, Governor Fort believes this canal would be capable of showing large profits on any investment which might be made in this property.

The Morris and Essex Canal connects the state of Pennsylvania with tide-water. At Easton it joins the Lehigh Canal, which has its source in the great anthracite coal fields and extends 102 miles, passing through the most fertile fields of New Jersey, serving Phillipsburg, Fort Morris, Oxford Furnace, Boonton, Paterson, Passaic, Newark and Jersey City. The total tonnage of this canal advanced from 554,034 tons in 1858 to 723,927 in 1864, while the coal tonnage advanced from 350,331 in 1859 to 459,175 tons in 1866. In 1864 the profits of this canal enabled the declaration of a dividend of 10 per cent. on both its preferred and common stock. In 1871 this property was acquired under lease by the Lehigh Valley R. R., for which an anual rental of 10 per cent. on the preferred stock and 4 per cent. on the common is paid. The cost of this property was $6,000,000. Immediately after 1871 the tonnage began to decrease rapidly, so that the last published records show that in 1902 the tonnage was 90,606, and its utility for transporting coal throughout New Jersey to tide water has been practically destroyed. It is problematical whether this canal can be resuscitated and developed into a paying proposition. A careful examination by competent engineers will evidence whether this can be accomplished or not.

The great demand for increased dock facilities in the port of New York has aroused much attention. An investigation of the possibilities of the utilization of Jamaica Bay, Long Island, has been made by a commission appointed by the Mayor of New York City. Many difficulties would be met in the preparation and maintenance of a proper entrance to Jamaica Bay which would not be encountered in the development of Newark Bay and the lower reaches of the Passaic and Hackensack rivers. The importance of developing this latter waterway can hardly be estimated. One of the most desirable features of its imrovement would be the connection afforded between the waterfront and the great railway systems, which have their terminii in New Jersey, and which connection could easily be obtained on reclaimed meadow land contiguous to Newark Bay.

The experience of the city of New York in the matter of dock improvements points very clearly to the great importance of immediate action by the state of New Jersey toward the acquisition and control of any improvements contemplated either on Newark Bay, or the lower Passaic or Hackensack rivers. New York first allowed the improvement of its waterfront to be accomplished by private interests and has since seen its error. Heavy expense has been entailed to the city of New York in acquiring at this late day the waterfront required for the conduct of its affairs which might have been secured at a nominal cost before improvements were made. In fact, the major portion of these rights were originally vested in the state and city, but were allowed to pass into the control of private interests, necessitating their reacquisition by the city.

Governor Fort considers the Federal Government should co-operate with the state of New Jersey in the development of this important territory. This is unquestionably the most efficient, economical and expeditious manner of affording relief to the port of New York, which, together with improvements at the mouth of the Raritan River, and to the Arthur Kull, between Staten Island and the Jersey shore, and to the Kill Von Kull, which affords direct communication to the upper bay of the New York harbor, a direct water channel will be provided from the port of New York to the Raritan River, and, with the proper development of the Delaware and Raritan Canal and the Delaware River, a most important link of the proposed Atlantic and inland waterways would be effected.

TABLE I.—THE PRODUCTS AND THEIR LOCATION RELATIVE TO WATERWAYS OF THE LARGEST CITIES OF NEW JERSEY.

Cities.	Mfg. products, annual value.	Waterway River.	Waterway Canal.
Newark	$150,055,227	Passaic	Morris
Elizabeth	29,300,801	Elizabeth	
New Brunswick	8,916,983	Raritan	D. & R.
Hoboken	14,077,305	Hudson	
Jersey City	75,740,934	Hudson	Morris
Trenton	32,719,945	Delaware	[a] D. & R.
Camden	33,587,273	Delaware	
Bayonne	60,633,761	Newark Bay	
Passaic	22,782,725	Passaic	
Paterson	54,673,083	Passaic	Morris
Phillipsburg	6,684,173	Delaware	Morris; Del. & Pa.
Perth Amboy	34,800,402	[b] Raritan.	

[a] Also feeder to D. & R. canal and Del. & Pa. canal.
[b] Also Arthur Kull and Raritan Bay.

In making any comparison of the cost of transportation by water and rail, consideration of transportation as applied to navigable rivers and deep waterways such as oceans, bays, sounds and estuaries, must be regarded as separate and distinct from transportation as applied to large and small artificial waterways and canals and canalized rivers, as the depth of water governs the size and tonnage of vessels, which, of course, also govern the cost. That the cost of transportation by water in large vessels or deep waterways has proven to be cheaper than transportation by rail is uncontradicted, so that a comparison need only be drawn between the cost of transportation on canals and navigable rivers and transportation by railroads.

Taking a tonnage of 3,000,000 (1,500,000 both east and west-bound) per season of 270 days, on a canal similar to the Delaware & Raritan at a speed of 3½ miles per hour, operating 24 hours per day, including all charges, interest, maintenance, etc., but not including cost of lockage and maintaining the canal proper. The cost per ton-mile is found to be 2.3 mills. These figures have been secured from electric operation of the Lehigh Canal at Mauch Chunk, Pa., during five months of 1907; by tests of electric haulage on the Erie Canal in 1905, and from the report by Sympher, Chief Engineer of Canals and Waterways of Germany, assisted by Engineers Thiel and Block, as given to the German Government on haulage for the Rhein-Weiser Canal. To this ton-mile cost must be added toll charge, to cover expense of employees to maintain and operate locks and canals, as well as taxes and interest on value of property.

As an illustration of the economy in water transportation, as compared with rail transportation, take the pounds pull exerted in moving a freight train of 25 cars, weighing 500 tons, loaded with 1,000 tons of coal, giving a total weight of train of 1,500 tons. It would require a locomotive weighing over 100 tons to properly handle such a train on level track. The pull exerted to move this train at a speed of four miles an hour is about the same as at twenty miles per hour; that is, the pull is higher at the slow speed and decreases until a speed of about ten miles per hour is reached, and then increases again as the higher speeds are reached. This engine exerts a drawbar pull of about 12,000 lb. in hauling a train of this tonnage.

On the other hand, take a cargo of 1,000 tons in two of the large, modern canal barges, weighing each 100 tons and giving a total load of 1,200 tons in boats and cargo. The pull necessary to move this combined load of 1,200 tons at a speed of 3½ to 4 miles per hour on a canal of fair dimensions would be only 4,800 lb., which, it will be noted, is only a little over a third of that exerted by the locomotive. This economy is due to the less resistance in the movement of boats through water; also to the fact that the weight of the boats is very much less than the weight of the cars—that is, the dead load is less for the same cargo carried. This comparison is best illustrated to the mind when one thinks of a small electric adhesion tractor weighing only about three tons, as compared with a mammoth, 100-ton locomotive, the former hauling a 1,000-ton cargo by water and the latter a 1,000-ton cargo on a railroad.

In this country but little has been accomplished to improve the method of propulsion on our artificial waterways. Excepting an extremely small percentage operated by steam, the same method of propulsion as existed in 1800, namely, the mule, has continued in operation up to the present date. The Old World has much to teach the New in the improvement, development, conduct and utilization of inland waterways as a useful auxiliary to its existing railways. Governor Fort did not recite at length the experience of France, Germany, Belgium and Holland in the creation and conduct of interior navigation, since all such data can be obtained from the consular reports. Attention was called, however, to the fact that, in strong contrast with our previous policy in this matter, the French and German governments, recognizing the importance of aiding in the development of their interior waterways, have rendered financial assistance not only in the construction and betterment of these utilities, but also in making tests of the different methods of propulsion. These tests, which have been made by eminent engineers who have been officially engaged in this work lead up to the following conclusions: 1. Barges operating with their own motive power show a much poorer economy than barges being towed. 2. Barges with storage battery show the least favorable results. 3. Towing by steam tugs or electric locomotives show practically the same economy. However, with the increase of traffic, electric towing costs decrease, while the cost of steam towing remains constant. 4. The question of prompt loading and unloading is very important in the saving of lay-day time on barges. With electric haulage installations, the available electric power furnishes cheap and convenient motive power for the operation of loading and discharging apparatus, and also for the operation of locks and elevators, thus decreasing the idle time of barges.

From these conclusions apparently it is necessary to look to electric power for the successful operation of our canals and canalized rivers. Governor Fort showed several photographs of the practical operation of electricity as a motive power on the Lehigh Canal at Mauch Chunk during 1907. He feels it is apparent that, in order to expeditiously and economically handle the immense tonnage which may be expected if our canals are operated under the liberal policy as advocated by the Conference, that their electrification must ensue. But, until this greater traffic is developed it will be necessary to provide a modified and cheaper form of installation to profitably carry the tonnage of the first few years until its increase will warrant the heavier carrying charges incident to the installation of electric motive power. To attain this end an adhesion tractor operated by a gasoline motor has been developed in this country which will operate upon the same monorail track as the electrically operated tractor, so that when the traffic of the canal has reached a volume sufficient to justify its electrification the electric motor may be substituted for the gasoline motor without any further change whatever in the installation. Practice indicates that when the traffic is below about 750,000 tons a gasoline tractor will prove a more economical installation; whereas, for tonnage in excess of this amount an electrically operated tractor is unquestionably more economical and efficient.

The question of inland waterways has aroused the interest of the entire state of New Jersey. The rapid growth and development of our industries during the past few years and the commercial prosperity that has been enjoyed have prompted the state and municipal officials and trade organizations as well as the leading men of affairs to advocate the improvement of the waterways of the state. Governor Fort considers that New Jersey is a unit upon this question. A great variety of solutions have been offered, and others are being planned which, if carried out, will eventually make the state a network of waterways.

There is in New Jersey a Rivers and Harbor Congress modeled after the National Rivers and Harbor Congress, which will served to concentrate all the influences at work within that state into one working organization. The New Jersey congress has been organized so as to provide for one vice-president from each Congressional district, while the board of directors is comprised of representative men of affairs. In the conduct of this association it is arranged that each Congressional district, through its representative, shall report on improvements desired, and if after investigation it is determined that the improvements requested will produce beneficial results the Rivers and Harbors Congress will lend its endorsement and assistance. This congress does not purpose favoring any particular locality, but rather the intention is to work on broad and comprehensive lines for the best interests of both state and country. This plan was said by Governor Fort to be meeting with the universal approval of the citizens of New Jersey.

The work which is being planned to develop the waterways contiguous to the city of Newark, the manufactured products of which covered every field of industrial endeavor, was considered worthy of special mention. Working in harmony with the Board of Trade, the Board of Works of Newark purpose the construction of a ship canal in the meadows contiguous to Newark Bay, which will serve to reclaim and develop this now practically useless swamp land. From an industrial point of view the provision which is being made for a series of meadow terminals, with manufacturing adjuncts, in Governor Fort's opinion, is perhaps the most important matter now receiving attention in New Jersey.

There are four ways of utilizing the meadows: 1. Terminals for railroads. 2. Terminals for steamships. 3. Warehouses at these joint terminals. 4. Manufacturing sites on the land adjacent thereto.

In connection with this undertaking, the construction of a ship channel from Newark Bay to the Hudson River, which work is now being done by the United States War Department, will operate to make the waters of the Newark Bay accessible to the shipping of the world. Still another waterway improvement to which attention was called is that of the construction of a tidal waterway from Manasquan Inlet to Bay Head. Surveys of this waterway have already been made. This improvement will create a harbor at Manasquan Inlet and provide a waterway from this point to Cape May. The desirability of this improvement in connection with the Bay Head-Cape May Canal is evident to all who have any knowledge of the New Jersey coast. New Jersey has appropriated $300,000 for this improvement at the session of the Legislature just ended.

But a few short years ago the coastline of New Jersey from Sandy Hook to Cape May was a series of barren sand dunes and land-locked waterways. With no financial assistance from the state, the enterprise of the citizens has created seashore resorts at which an annual expenditure of many millions of dollars is made by the citizens of this nation who visit these resorts in search of health and recreation.

Governor Fort recommended that each state having water facilities within or contiguous to its borders should appoint a waterways commission, in which engineering ability should predominate, to carefully investigate and make physical examination of existing waterways, and, after consultation with the State rivers and harbors congress and the various boards of trade and commercial bodies, should arrive at some definite conclusions upon which to recommend plans for improving these waterways, either as feeders to, or as a component part of, the contemplated deeper waterways plan which has been outlined by the various inland and deeper waterways commissions.

SMALL CONCRETE STRUCTURES built by force account on the Truckee-Carson irrigation project have their costs analyzed in the "Reclamation Record" for June. The concrete was mixed 1:2:4, and a small amount of steel reinforcement was used in one of the structures, the cost of which is included in that of the concrete. The sand was hauled from ¼ to ½ mile, the crushed stone from 7 to 8 miles and the cement from 10 to 11 miles. In one of these structures 32 cu. yd. of concrete were used, which cost in place $12.39 per yard; the forms cost $5.26 per cubic yard, and the labor of placing them cost $25.41. In a second structure the unit cost for the concrete was $14.08, the cost of the forms was $3.22 per cubic yard of concrete, and the cost of placing the forms amounted to $21.84. These figures do not include the cost of supervision by foremen, but include the wages of the concrete workmen at the rate of $2.50 per day.

The First Case under the Pennsylvania River Pollution Law.

The Pennsylvania Supreme Court has just decided the first suit brought under the 1905 law to preserve the purity of the rivers of the State. Some critics have held that this statute was too sweeping in the powers given to the Commissioner of Health to be upheld by the courts, but this first judicial interpretation of it seems to confirm the legality of the act, so far as it relates to the prevention of the pollution of rivers. The statute prohibits any person, corporation or municipality from discharging sewage into the waters of the State except under the conditions which it enumerates. For the purposes of the act, sewage is defined to be any substance which contains the discharges from the bodies of human beings or animals. The act specifically states that it does not apply to waters pumped or flowing from coal mines or tanneries, nor does it prevent the discharge of sewage from systems owned by municipalities provided such systems were in operation and discharging sewage into the waters of the State at the time of the passage of the act. This exception does not permit the discharge of sewage from a municipal system extended subsequent to the passage of the act. The law provides that all individuals, private corporations and companies that, at the time of the passage of the act, were discharging sewage into the waters of the State, might continue to do so unless, in the opinion of the Commissioner of Health, this discharge of sewage might become injurious to the public health. If the Commissioner believed that any such discharge was injurious he was given authority to order its discontinuance, and after such an order was issued, ten days were allowed to elapse before any further discharge of the sewage became a misdemeanor, punishable by fine or imprisonment or both. Any such order of the Commissioner of Health could be appealed to the Court of Common Pleas of the county wherein the outlet of the sewer was located. This court was given the power to hear the appeal and to affirm or set aside the order or to modify it.

The case in question, Emmers vs. Commonwealth of Pennsylvania, was brought by the owner of a hosiery mill employing from 150 to 200 hands and discharging the sewage of these employees directly into the Schuylkill River. In February, 1906, the Commissioner of Health notified him to cease discharging sewage into the river, but the mill owner neither complied with this order nor appealed from it to the Court of Common Pleas, in accordance with the right given him by the statute. Suit was accordingly brought against him by the Commissioner of Public Health, and after being carried through the various courts of the State has just been decided by the court of final jurisdiction. The contention of the mill owner was that because the statute permits water from coal mines or tanneries and the sewage from municipal systems to be discharged into any of the waters of the State, while forbidding individuals, corporations and companies to discharge sewage into the same waters, the law is contrary to the 14th amendment to the Constitution of the United States and Section 7, Article 3, of the Constitution of Pennsylvania. The 14th amendment declares that "No State shall make or enforce any law which shall abridge the privileges or immunities of citizens of the United States; nor shall any State deprive any person of life, liberty or property without due process of law; nor deny to any person within its jurisdiction equal protection of the laws." The clause in the State Constitution referred to prohibits the Legislature from passing any law, "granting to any corporation, association or individual any special or exclusive privilege or immunity."

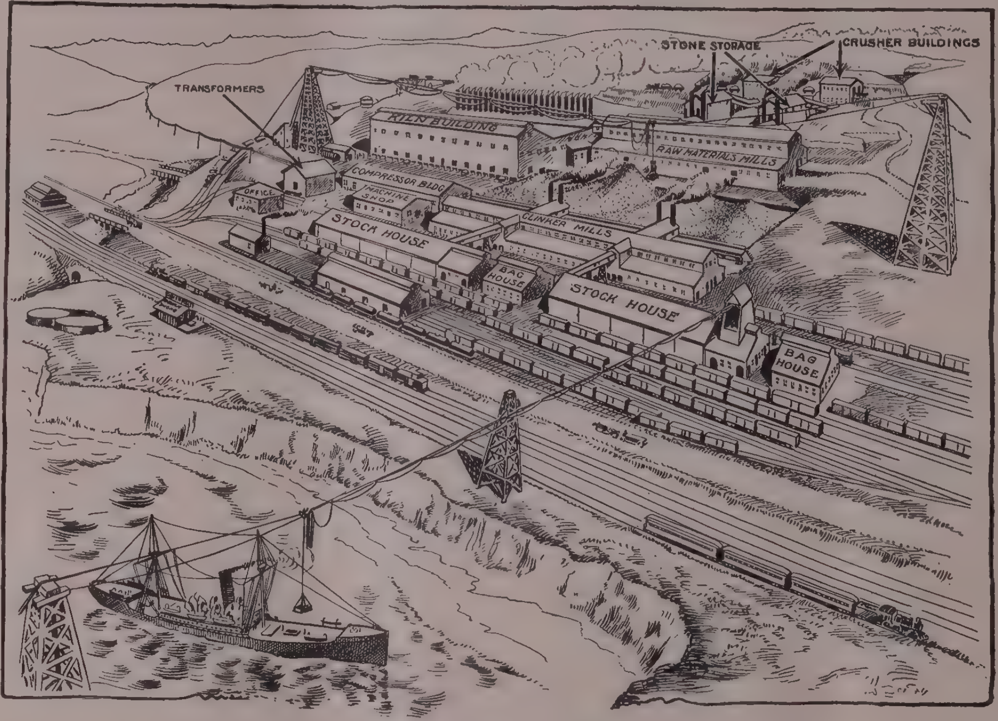
The courts ruled that the only alleged immunity of the mill owner with which the statute in question could possibly interfere is that of discharging sewage from his lands into a stream constituting one of its boundaries. It is ruled that this alleged right is not among the privileges and immunities which belong to him as a citizen of the United States, as distinguished from those of the citizens of the State in which the land and the stream are situated. The pollution caused by the mill owner did not result from the development of any natural resources of his land, nor was it unavoidable. The defendant was not, prior to the enactment of this statute, possessed of a right of property in the privilege of discharging sewage into the stream, recognized by law, and he was not therefore deprived of "liberty or property" within the meaning of the 14th amendment. Moreover, even if he had such a property right, he was not in this case deprived of it, "without due process of law." The statute provided that he had the right of appeal to the county court, but he did not take advantage of this right. The courts have further ruled that there was nothing in this statute which denied to the mill owner the equal protection of the laws. The statute was passed in the exercise of the police power of the State, which extends to all regulations affecting the health, good order, morals, peace and safety of society. The preservation of the waters of the State from pollution, involving danger to health, is a proper subject for the exercise of this police power. The courts ruled that the waste liquids from coal mines and tanneries do not come under the definition of sewage given in the statute, and as they do not contain the germs of diseases, their exception from the operation of the statute was entirely legal.

The contention of the mill owner that the statute is a special law granting privileges for municipal sewage systems that are denied to individuals, and is therefore contrary to the State Constitution, is also overruled. The construction of sewage systems is essential to the development of communities, and the regulation of such works imperatively demands the exercise of the police power of the State. Any person whose property suffers an injury because of the discharge of sewage into a stream is entitled to compensation for such injury. This statute does not deprive a private owner of that right. It was contended by the mill owner that if the Commissioner of Health has the right to order his private sewage system to be provided with some other outlet than the Schuylkill River, the Commissioner must also prohibit the discharge of all sewage, under every conceivable circumstance, into the waters of the State. Any such interpretation of the law would deprive the State of all power to make necessary police regulations to meet the various needs of different communities. Moreover, municipal corporations do not come within Article 3, Section 7 of the Constitution of Pennsylvania, but fall within the control of another article relating to them specially. Municipal and quasi-municipal corporations are the agents of the State, the court points out, authorized to perform such governmental duties as are delegated to them by the State, and legislation may confer upon municipalities powers and privileges which are properly denied to individuals and private corporations.

THE DISCHARGE OF SEWAGE into a river for a period of years does not give a city which is practicing this method of disposal any specific rights to the undiminished flow of the stream for the purpose of diluting the sewage. This decision was recently made by Vice-Chancellor Emery in the suit of the City of Paterson against the East Jersey Water Co., for an injunction to prevent the company from diverting water from the river into which the municipal sewers discharge.

A 12,000-Barrel Cement Mill in California.

The new mill of the Santa Cruz Portland Cement Co. at Davenport, Cal., with a normal daily capacity of 12,000 barrels of cement, is the largest mill on the Pacific Coast and one of the largest of those that have been built recently in this country. The arrangement of the buildings of this mill and the design of the mechanical equipment in these buildings are based on the results of experience in the construction and operation of the various other cement mills of the same interests that have built this one. The design of the mill, however, was controlled by three governing features. The first and most important of these was to maintain the character of the output under all conditions of operation; the second was to obtain a large production for the amount of equipment installed; and third was to make cement for the least possible cost consistent with the good results made possible by the other controlling features of the design. The uniformity of the raw materials available, the topography of the site of the mill and other conditions combined to permit these requirements of design to be met most satisfactorily.



The Completed Mill of the Santa Cruz Portland Cement Company.

The site of the mill is on the shore of the Pacific Ocean, 11 miles north of Santa Cruz and about 80 miles in a direct line from San Francisco. The ocean shore in the vicinity of the site is quite precipitous, the ground rising abruptly from the edge of the water to a height of 50 to 75 ft. The top of the bluff thus formed is fairly level at the site for several hundred feet back from shore; in the rear of this open, level space the ground slopes up to hills that continue almost uninterruptedly back to the Coast Range Mountains. The mill buildings are arranged on the level space and on the rise to the first hill in such a manner as to obtain to considerable extent the advantage of the slope of this hill in handling materials. Low-lime and high-lime rock are mixed to obtain the proper character of raw materials to produce the desired quality of cement. The low-lime rock is obtained from a quarry adjacent to the site, while the high-lime rock is quarried from a deposit 2.8 miles back in the hills and is delivered to the site in cars on a standard-gauge railroad bult specially for the purpose.

The character of the raw materials from which the cement is made is not only remarkably uniform, but is such that these materials can be handled through the mill very economically. The deposit of high-lime rock owned in connection with the mill covers an area of 8,000 acres in the hills back of the site, providing a practically inexhaustible supply. The continuity of this deposit and the uniformity and good character of the rock contained in it are specially notable in the region in which the mill is located. The rock is an almost pure crystalline formation of lime that exists over the entire 8,000 acres in an uninterrupted deposit of great depth that is almost entirely free of other materials. The nature of the rock is also such that it can be blasted readily in the quarry and crushed easily in the mill.

A quarry has been opened at the edge of this deposit closest to the mill and the standard-gauge railroad built to the latter from this quarry. The site of the quarry is immediately upstream from the mouth of a deep, narrow gorge, having nearly vertical sides that rise to a height of 600 to 800 ft. above the bed of the stream in the bottom of it. The railroad approaches the site on a bench cut in one side of the gorge, the track being about 40 ft. above the bed of the stream at a tipple which has been erected across the mouth of the gorge. The latter was accordingly filld up to the level of the railroad track with loose rock obtained in opening the quarry and in clearing a site for the tipple in the steep hillsides. A level working space was thus obtained, 40 ft. above the original bottom of the gorge, on which is provided sufficient room to carry four parallel standard-gauge railroad tracks under the tipple, the water of the stream passing through the loose-rock fill.

The top floor of the tipple is 80 ft. above the level of the four railroad tracks, and the quarry is worked in the sides of the gorge at or above the level of this floor. In order to obtain a working space at this level the gorge had to be filled with the rock loosened in opening up the quarry. The latter is at present worked by hand, although a steam shovel will be installed as soon as there is sufficient working room on the floor of the quarry to handle the loosened rock from the working face into cars. The blast holes are all made with Little Jap pneumatic hand drills, as the rock is soft enough to preclude the necessity of tripod drills. The rock is loosened at the working face in large quantities by occasional extensive blasts, which are placed in working chambers in two branches of a single-entry tunnel, these branches being driven in both directions from this entry and parallel with the face of the quarry. The large boulders resulting from these blasts are afterward broken by small blasts as they are reached. Air for driving the drills is delivered from compressors at the cement mill by a 6-in. wrought-iron pipe line, 2.8 miles long.

The quarry, the tipple and the railroad leading to the mill are all arranged to handle 10,000 tons of rock every 24 hr., as a considerable amount of rock from the quarry is marketed for general purposes. To this end the tracks in the quarry are arranged and the tipple is built to handle continuously a large output. As only the excess over the demands of the mill is sold, the supply for the latter can be maintained easily.

The top floor of the quarry carries three parallel 30-in. gauge tracks, which connect at both ends with the main running track in the quarry. This track is laid in a circuit from one end of the tipple along one side of the gorge, across the working level of the quarry and back to other end of the tipple. Branch tracks are extended from it at desired intervals to the foot of the working face of the quarry. The 5-ton steel-body and steel-frame side-dump cars in which the rock is handled from the quarry to the tipple are thus taken on at one end of the tipple and off at the other end, without interference. The branch tracks from the main running track also permit the latter to be kept in continuous service, although the branch tracks may be covered occasionally by a blast.

Two Views of the First Unit of the Mill Prior to Inception of Construction of the Second Unit.

The tipple is a five-story timber-frame structure built to fit across the narrow gorge at its site. It is 40 ft. wide, 57.5 ft. long at the level of the four standard-gauge tracks which pass under it and 180 ft. long at the level of the top floor, the height between these two track levels being 80 ft. Space is provided in the tipple for a crusher at each end of a storage bin, 40 x 60 ft. in plan and 37 ft. 10 in. high, erected over the four railroad tracks. The feeding hoppers of these crushers are arranged to open on the fourth floor of the tipple, where the stone is fed into them automatically from the piles into which it is dumped from the quarry cars on the floor above. One of these crushers is in operation and provisions have been made to install the other. The one in operation is a No. 9 Gates gyratory crusher, which is belt-driven by a 150-h-p., three-phase, alternating-current, continuous-speed Westinghouse motor in a tight house on the third floor of the tipple. This crusher stands on a concrete base, 14 ft. 8 in. high, that is carried by a rubble masonry footing, over 50 ft. in height, on a bench cut in the steep side of the gorge.

The discharge from the crusher passes over a grizzly into the storage bin, the coarser stone being diverted by this grizzly to one side of the bin, in order to meet the demands for certain classes of consumers supplied with commercial stone. The bottom of the bin is divided into four transverse hoppers, one over each of the railroad tracks under the tipple. Five 24 x 24-in. gate openings are arranged in each of these hoppers, so stone may be drawn rapidly from the bin into cars.

The standard-gauge railroad that extends from the tipple to the cement mill is of first-class construction and involved a large expenditure, owing to the topography of the country through which it is built. The portion of the road in the vicinity of the quarry is almost entirely in a bench cut in the steep side of the canyon. This cut was made largely in solid rock at a height of 150 to 200 ft. above the bottom of the canyon. In the remainder of the distance to the mill the line follows across the drainage, thus involving considerable heavy grading and several high trestles. Most of the latter can eventually be replaced, however, by embankments, and, as two hose connections to a water-supply pipe line leading to the mill are made at each of them, they are well protected from fire. Notwithstanding the difficult character of the country traversed by this railroad, the grades obtained on the latter are particularly satisfactory, no adverse grade to the loaded trains going to the mill being presented, while the grades against traffic toward the tipple have a maximum of 2 per cent., although for most of the distance the ascent is much more gradual than the maximum.

The track is laid with 70-lb. rails on sawed ties, with tie plates, and is rock ballasted, so that good speeds can be maintained safely. Double-truck steel-frame and steel-body side-dump cars, with a rated capacity of 20 tons, are used to haul the stone from the tipple to the mill. These cars are handled in trains by a 40-ton Porter locomotive. A second locomotive of the same type is also to be installed, in order to provide against emergencies.

The cement mill consists of two independent units, made up of two separate groups of buildings, each unit having a capacity of 6,000 barrels a day. These two units have exactly the same equipment, which is arranged in the same manner in both, the corresponding principal buildings of the two being in conjunction, although distinct. One of these units was finished in April, 1907, as a separate complete mill, but was built to provide for the addition of the second unit without interfering with its operation during construction. The construction of the buildings of the second unit, which was commenced soon after the first one was placed in operation, was approaching completion at the time this description was prepared. The satisfactory operating results obtained on account of the design and arrangement of the first unit is evident from the fact that no changes of plans were made when the construction of the second unit was started.

Each 6,000-barrel unit of the mill embraces the following buildings: A crusher building, a crushed-rock storage bin, a dryer building, a raw-materials grinding building, a clinker-grinding building, a cement stock house and a power station. The kilns for both units are in one building, and a single clinker storage is provided for the two units. The kiln building and the clinker storage are arranged, however, so either unit may be operated entirely independent of the other.

The railroad from the tipple at the high-lime rock quarry terminates in two switch tracks, laid in a level bench on the hill back of the mill. One of these tracks extends through the crusher building of one unit of the mill and the other through the same building of the second unit of the mill. The main track also connects near these buildings, with a spur leading to a tipple over a storage bin, from which cars are loaded with crushed stone for the market.

The arrangement of the two units of the mill is the same from the crusher building to the kiln building, so only one of the units will be described. The track at the crusher building is generally parallel with the ocean shore line in front of the mill and is at an elevation that permits stone to be dumped from cars on it into a hopper from which crushers on the floor below are supplied. The low-lime rock quarry has been opened in a hill directly back of the crusher building. The entire country in the vicinity of the mill is, however, composed of an immense deposit of shale rock, which is of remarkably uniform character throughout. The chemical composition of the shale is such that it can be mixed with the high-lime rock from the quarry farther inland to produce a combination of raw materials particularly well adapted for making a Portland cement of uniform character. Furthermore, this rock is also quarried and crushed easily, so it can be handled at a minimum expense.

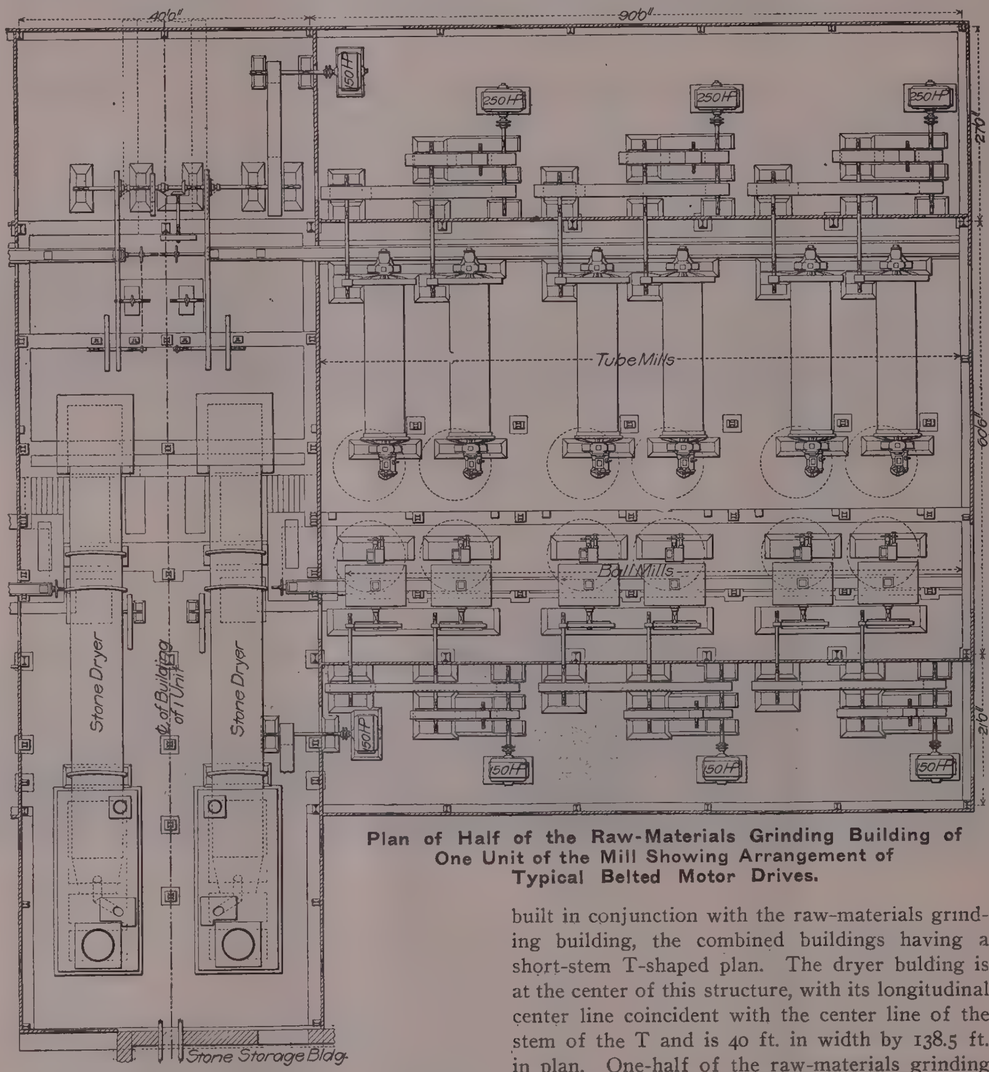
The shale rock quarry that has been opened is at present operated by hand, but the intention is to install a steam shovel to load the quarry cars. The latter are similar to those used in the other quarry and are operated on a system of branch tracks extending from the working face of the quarry to a main track that leads up an incline to the crusher building. The cars are hauled up this incline track by a double-drum Flory hoist geared to a 95-h.p. General Electric variable-speed alternating-current motor. The incline track extends into the crusher building on the same floor with the standard-gauge track on which the high-lime rock is delivered, the two tracks being parallel and close together on this floor.

Contrary to what is perhaps considered usual practice, the high-lime and low-lime rock are proportioned in the crusher building. The remarkable uniformity of both kinds of rock and the means provided to insure the complete mixture of the two, as well as the maintenance of the proportions when once established, are considered to produce far more satisfactory results than could be obtained by attempting to mix the raw materials after they had passed the grinding mills. At the same time, a much more satisfactory arrangement of equipment and more economical operating conditions are also made possible.

The chemist employed to determine the results of the various operations of the mill makes regular analyses of the rock from both quarries to ascertain the proportion to be used from each quarry. On account of the uniform character of the deposits, these proportions rarely have to be altered more than a few per cent. from a normal ratio. Based on the results of these analyses, the two kinds of rock are proportioned on the floor of the crusher building. Each of the tracks in the latter contains a track scale, the beams of the two scales being together between the two tracks. When a car of high-lime rock has been placed on the standard-gauge track scales and weighed, a car of low-lime rock is placed on the scales of the other track and trimmed to a weight that will produce the predetermined proportions. The standard-gauge cars are arranged with double dumping doors in both sides, and the other cars with a single door on each side, so the same proportionate amount of each kind of rock may be dumped simultaneously into a track hopper below. As the physical character of the two kinds of rock is quite similar, segregation of the materials in the hopper is avoided.

Two No. 6 Gates crushers are supplied directly from the track hopper. Both of these crushers are belt-driven by a 150-h.p. alternating-current continuous-speed Westinghouse motor. The motors are in a compartment above, separated from the crusher room by tight partitions. The two crushers both deliver to one 24-in. inclined conveyor belt leading to the crushed-rock storage building on the downhill side of the crusher building. Whatever separation of the two kinds of rock that may occur in the track hopper is thus greatly neutralized by having the two crushers deliver to the same conveyor. The latter is belt-driven by the motors which drive the crushers.

The conveyor belt is 176 ft. long between end pulleys and extends on a grade of 20 per cent. through a covered overhead bridge to the upper part of the crushed-rock storage building. The latter is 77 x 61 ft. in plan and rises to a height of 33 ft. at the eaves line above the bottom of the storage bin. The conveyor belt is arranged to deliver at the top to a hopper, with four discharge chutes leading out of it, the flow through each of these chutes being controlled by a gate. Two of the chutes are set to discharge directly into the storage bin, one on each side of the center line of the latter. The other two each discharge into one of two conveyor belts that are placed longitudinally over the bin, one toward each side. These conveyor belts are arranged with automatic traveling trippers, which move continuously from one end to the other of the structure and thus distribute the crushed rock uniformly over the entire bin.



Plan of Half of the Raw-Materials Grinding Building of One Unit of the Mill Showing Arrangement of Typical Belted Motor Drives.

Although the proportions of the raw materials established in the crusher building are in this manner well maintained, the method of drawing the materials from the crushed-rock storage bin further insures a complete mixture to be secured. The bottom of this bin is 10 ft. above the floor of a basement under it and is built in the form of five transverse hoppers. Each of these hoppers is provided with a row of five outlet openings through the floor of the bin, the openings being spaced equal distances apart in both directions. Each of these outlet openings is controlled by an automatic feeding gate, and under each transverse row of openings is placed a 20-in. horizontal conveyor belt. The automatic feeding gates are chain-driven from the same shaft which operates the conveyor belts, with their drives arranged so any of them delivering to any belt may be operated independently. The transverse conveyors are also each driven from the one main shaft by means of a friction-clutch pulley, so they can be operated without reference to each other. These cross conveyors all deliver to one 24-in. conveyor belt that extends longitudinally along one side of the space under the bin into the dryer buildings. The whole arrangement of the crushed-rock storage bin is therefore such that the materials are delivered to it at the top from one conveyor along two longitudinal lines and then taken from the bottom of it through five transverse rows of equally spaced openings that all deliver to a single conveyor leading to the dryer building. In this manner the mixture of the two classes of rock is further extended greatly.

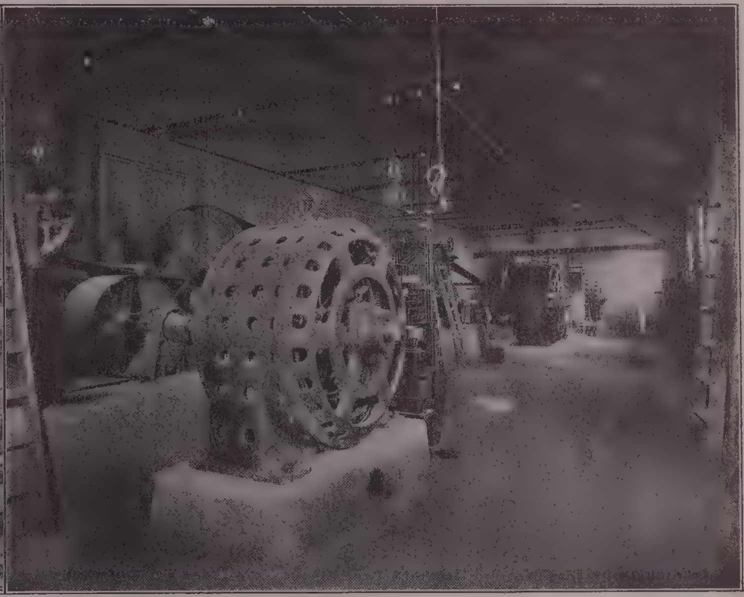
The dryer building of each unit of the mill is built in conjunction with the raw-materials grinding building, the combined buildings having a short-stem T-shaped plan. The dryer bulding is at the center of this structure, with its longitudinal center line coincident with the center line of the stem of the T and is 40 ft. in width by 138.5 ft. in plan. One-half of the raw-materials grinding building is on each side of the dryer building, each half being 90 x 108.5 ft. in plan. The one end of one-half of the raw-grinding building of this unit also joins one end of half of the raw-grinding building of the other unit of the mill, thus forming a continuous structure 440 ft. in length. The buildings of the two units of the mill are, however, entirely distinct, so far as operation is concerned.

The dryer building is in each case in one large room, which is entirely separated from the two halves of the raw-grinding building by tight wooden partitions. The interor of each of the two halves of the raw-materials building is separated into three rooms by two tight partitions, one large central room for the grinding mills, with a narrower room on each side of this one for the motors which drive these mills and also the equipment in the dryer building.

The conveyor belt that delivers the stone from the outlet system of the crushed-rock storage bin to the dryer building discharges into a hopper having two chutes, each of which supply a 7.5 x 60-ft. rotary dryer. The two latter are both fired with crude oil, which is supplied at a pressure of 80 lb. per square inch, and are each served by a 4-ft. steel stack, 60 ft. high. They each deliver through a space in the brick setting at their rear end to the foot of a vertical bucket elevator and are arranged so either dryer can be served by either elevator. The latter are both enclosed in steel housings, each of which has a connection at the top with an exhaust fan that draws off the dust in the housing and delivers it to the bottom of the elevator again. The two elevators serving the dryers each deliver to a continuous over-lapping bucket conveyor extending into the half of the raw-grinding building on the corresponding side of the dryer building; either elevator can also deliver to either conveyor.

The conveying system which delivers the stone from the crushed-rock building to the dryers, the latter and the elevators that deliver the dry stone to the bucket conveyors are all driven by a 150-h.p. alternating-current, continuous-speed Westinghouse induction motor. This motor is in one of the narrow, tightly enclosed rooms on the uphill side of the raw-grinding building, where it is entirely separated from the dryer and grinding equipment. The motor is direct-connected to a line shaft that extends through the partition on the dryer room side and is belted to jack shafts, from which the various units are separately belt-driven. Each drive is arranged with a friction-clutch pulley, in order that any unit may be operated independently of all others of the group. The motor and line-shaft bearings are on concrete footings; the jack-shaft bearings at the floor level are also on concrete footings, while the jack shafts above that level are carried on mezzanine concrete floors supported by the steel frame of the building. This arrangement of drives and shafting is typical throughout the mill.

The Tipple at the High-Lime Rock Quarry.



Typical Belted Motor Drives in Mill Buildings.

The over-lapping bucket conveyor extending from the dryer elevators into each half of the raw-grinding building continues horizontally over a row of supply bins for a group of ball mills. Space is provided in each half of the building for a row of six ball mills, although only four of the six have been installed in each case. These are No. 8 standard Gates mills, which are driven in pairs by 150-h.p. alternating-current, continuous-speed Westinghouse induction motors. The latter are placed in the rear of the partition which separates the main room of the building from the motor room. They are belted to two line-shafts that extend through this partition to a gear drive on the shaft of the ball mills. One of these line-shafts is only 10 ft. on centers from the shaft of the motor, but, by using extra wide driving pulleys and belts, with an idler pulley, no difficulty whatever has been experienced with this arrangement in operation.

The ball mills are equipped with automatic positive feeding devices to insure that the raw materials are supplied to them at the proper rate. The mills all discharge into one screw conveyor that extends under the elevated floor on which they are placed and back into the dryer room, delivering to an inclosed vertical bucket elevator. This elevator raises the partially ground materials up to an overhead screw conveyor that extends into the corresponding half of the raw-grinding building again, over a row of supply bins for six 5.5 x 22-ft. tube mills. The dust which is deposited in the dust-collecting chambers at the stack end of the dryers is delivered from each of these chambers through a screw conveyor that delivers in turn to the bucket elevator handling the product of the ball mills to the overhead screw conveyor. This dust is thus continuously returned in a small volume instead of occasionally being replaced in large amounts, as is generally done.

The tube mills are also gear-driven from line-shafts belted to motors arranged the same as in the case of the ball mills. Each pair of tube mills has a 250-h.p. alternating-current, continuous-speed Westinghouse motor. These three motors are placed in a tight room on the opposite side of the machinery room from one containing the motors driving the ball mills.

The output of each row of six tube mills is carried back into the dryer room by a screw conveyor, placed under the floor, that delivers to an inclosed bucket elevator. This elevator discharges at the top into a hopper supplying an overhead screw conveyor leading to the kiln building. The two elevators serving the two sets of tube mills in the two halves of the raw-grinding building of each unit of the mill both deliver to one screw conveyor, which transports the entire output of the raw-grinding equipment of that unit to the kilns. The continuous mixing that occurs before the materials reach the dryers is thus continued until this final conveyor is reached, since the materials are variously separated and mixed again in passing through the dryer and grinding buildings.

The various units of the conveying equipment, from the elevator delivering to the screw conveyor that supplies the tube mills to the screw conveyors leading to the kilns, inclusive, are all driven from a line-shaft belted to a 250-h.p. alternating-current, continuous-speed Westinghouse motor in the same room with the motors of the tube mills.

The arrangement of the equipment in the buildings of the second unit of the mill, which unit is now approaching completion, is exactly the same as that of the first, from the crusher building to the screw conveyor leading from the raw-grinding building to kilns. The crusher building of this unit is adjacent to the one of the first unit, and the two crushed-rock storage bins have corresponding locations in both units. The two raw-grinding buildings, as stated before, are built with their adjacent ends together.

The kilns for the two units of the mill were all placed in a single building at one end of the mill, chiefly because the site did not offer a suitable location for half of them to be located in a corresponding position at the other end of the mill. This kiln building is 170 x 356 ft. in plan and contains twenty-four kilns, which, it is believed, is the largest number of cement kilns under one roof in this country. The twenty-four kilns are side by side in one long single row, with all of them at the same level. Each kiln is 125 ft. long, 7 ft. in diameter at the charging end and 7.5 ft. in diameter at the firing end. They are each carried by four ring bearings on concrete footings resting on a solid rock ledge. Each kiln is served by a 5-ft. steel stack, 80 ft. high, which is on a brick base at the end of the kiln. The hoods at the firing ends of the kilns are each mounted on a four-wheel truck, in order that they may be drawn back readily on a concrete floor along that end of the kilns, when the latter have to be entered for any reason. The kilns are fired with crude oil under a pressure of 75 to 80 lb.

The twelve kilns of each set are driven by a single 100-h.p. alternating-current continuous-speed Westinghouse induction motor. One of the motors is at one end and the other at the opposite end of the building, each of them being in a tight room built against the end of the building. Each motor is belted to a driving pulley on a line shaft that extends transversely across under the twelve kilns which the motor drives. The drive gearing of each kiln is belted to a pulley on the line shaft, which pulley is arranged with a friction clutch so that any one kiln may be operated independently of the others of the set.

The two screw conveyors which deliver to the kilns from the raw-grinding buildings of the two units of the mill extend over a row of supply bins at the charging ends of the kilns. Each of the kilns is supplied from these bins by a screw conveyor belt-driven by a pulley on the same clutch which drives the kiln, so the rate of feed is always in a constant ratio to the speed of the kiln. The latter are, however, arranged to operate at a continuous speed, since experience in the operation of kilns in other mills caused the designers to consider this the most feasible method.

A row of twelve upright coolers is placed along the rear of the broad concrete platform at the discharge ends of the kilns, each of these coolers serving a pair of kilns. At the same time, each kiln of a pair is operated entirely independent of its mate. The clinker falls from the ends of the kilns into a narrow connection with the concrete-lined boot of a bucket elevator that raises it to the top of the cooler. One elevator is provided for each pair of kilns, and is driven by a wire-rope transmission on a sheave wheel on the line shaft driving the kilns.

The coolers are each 10 ft. in diameter and 34 ft. high. They stand on concrete footings on the rock ledge and deliver at the bottom into temporary storage bins. The coolers are supplied with an air-cooling blast from blowers in the power station.

The buildings of the mills thus far described are on a side hill, the slope of which reduces gradually, coming down from the crusher building. The long combined raw-grinding buildings of the two units of the mill and the long kiln building are approximately in line at the base of this slope. An excellent opportunity to obtain a desirable clinker storage space on the downhill side of these buildings was therefore presented, and has been availed to the fullest extent. A 1,200-ft. span Flory cableway, carried by two stationary towers, each 160 ft. high, has been erected over the longitudinal center line of a space 200 ft. wide, thus providing an opportunity to store clinker on an area 200 x 1200 ft. in plan to a height of 100 ft., or the clearance of the cableway, in which area 1,000,000 barrels of clinker can be placed.

The temporary storage bins under the coolers at the kilns are placed with their bottoms 7 ft. above the level of the clinker storage space, in order to provide room to draw the clinker from openings in the bottoms. One 12-in. circular opening is placed in the bottom of each bin, and is controlled by an under-cut gate operated from the ground level. The cableway handles steel skips, which have a capacity of 25 barrels each and are loaded from the drawing gates in the bins. Standard-gauge tracks are extended under the gates, normal to the axis of the cableway, one track to each gate. These tracks carry flat cars on which the loaded skips are pushed out to within the range of the cableway. The skips can, of course, be dumped at any point along the travel of the cableway. This arrangement permits the clinker to be mixed most completely, as each successive skip load comes from a different kiln and can be deposited in a different place from the preceding one.

The method of drawing the clinker from the storage pile is such that the clinker is still further mixed to a great extent. Since the cableway deposits the clinker along the longitudinal axis of the storage space, the most desirable method of drawing clinker from that space to insure thorough mixing is in transverse sections. This is accomplished by concrete-lined tunnels extending transversely under the storage space. Fourteen of these tunnels, each 6.5 ft. wide by 7 ft. high and 200 ft. long, have been built, 25 ft. apart on centers; the remainder of the storge space will be similarly equipped later, if necessary. Each of these tunnels has a row of openings, 1 ft. square, in its arch, which are spaced 12 ft. apart and are each controlled by an under-cut hand-operated gate. The clinker drawn through these openings falls on a 20-in. conveyor belt in each tunnel, the various belts all delivering to a longitudinal 24-in. conveyor belt along the ends of the tunnels distant from the kiln building. Two of these longitudinal belts are provided, one traveling from each end of the row of tunnels to a common discharge into a hopper supplying a 24-in. conveyor belt that leads into the finishing mill. The whole set of these conveyors is operated by a counter shaft which is also driven by a 150-h. p. Westinghouse constant speed induction motor. Each of the conveyors in the tunnels is arranged with a friction clutch on the driving shaft so it can be operated independently of the remainder.

The clinker mill building of each unit of the mill is of the same size and arrangement as the combined dryer and raw-grinding building; the two clinker-mill buildings of the two units are also built together, the same as the raw-grinding buildings. The 24-in. conveyor belt that carries the clinker into the building delivers to a supply hopper for a 7.5 x 60 ft. rotary dryer. A space for a second dryer of the same size is also provided, in case more drying capacity is required. Beyond these dryers the conveying, grinding and motor equipment in this building is an exact duplication in size, design and arrangement of the same equipment in the raw-grinding building. The screw conveyor in the latter building which transports the product of the tube mills to the kilns in this case delivers the finished cement to a stock house on the ocean side of the buildings.

The plans for the mill contemplate an 80 x 306 ft. stock house, with a capacity for storing 125,000 barrels of cement, for each unit of the mill. The screw conveyor from each finishing mill to its stock house will extend longitudinally over the bins in the latter and deliver at any desired point. The stored cement will be drawn from the bottom of the bins into cross screw conveyors extending to a 80 x 54-ft. sacking house between the two stock houses. A railroad switch track will be laid on each side of this sacking house, in order that the cement may be loaded directly into railroad cars.

The shipping facilities available at the mill are all that could be desired. The Southern Pacific R. R. has built a 12-mile extension to the mill from Santa Cruz and has made arrangements to handle the traffic produced by constructing a long switch yard in front of the mill, and by extending several sidings into the latter. The extension connects at Santa Cruz with a branch joining the main Coast Line of the Southern Pacific, and also with the direct line of that company over the mountains to San Francisco, which latter line has been under reconstruction since the earthquake in 1906. The Ocean Shore R. R., which is being built from Santa Cruz to San Francisco, passes along in front of the mill where its facilities can be utilized later, if desired. It is also possible to obtain a 40-ft. depth of water in the ocean by constructing a pier, 1,600 ft. in length, from the shore line, so water transportation can also be secured.

The electrical power to operate the mill is purchased from the Bay Counties Power Co., which company has built an independent transmission line, 40 miles long, to deliver the 60,000-volt three-phase alternating-current that is supplied. Two parallel separate branches of this line are extended to the mill from a switching station on the hills about two miles back from the ocean, current being delivered over one branch at a time. Long, dry and dusty periods broken by occasional heavy fogs from the ocean offer a menace to transmission lines in the stretch of the country covered by the parallel branch lines, but the latter greatly reduce the danger of a shut-down of the mill on this account, since only one of them is in service at a time.

The incoming 60,000-volt current is stepped down to 2,000 volts by three 1,100-kw. oil-insulated and water-cooled transformers in a separate building with a concrete floor and concrete side walls. The 2,000-volt current is delivered to various parts of the mill on over-head circuits. A circuit breaker and a starting box are provided on a board adjacent to each motor. Reference has already been made to the general type and arrangement of the motors. The latter are all stock standard Westinghouse induction motors, which being placed in separate tight rooms where comparatively little dust reaches them give practically no trouble in operation. Moreover, a motor of this type is so simple in construction that it needs no protection, except dust guards for the bearings. The wiring and automatic protection devices are also inclosed in such a manner as to eliminate danger of fire risk due to sparking.

The conveying system throughout the mill, which system was built by the Webster Mfg. Co., of Chicago, after designs furnished by the engineers of the cement company, is arranged to produce the highest efficiency and the least dust possible. Excepting the conveyor belts, the units of the entire system are thoroughly enclosed. The screw conveyors are in covered trenches in the floor, wherever feasible, and elsewhere in tight sheet-steel housings. The bucket elevators are also in tight sheet-steel housings.

Crude oil for firing the kilns and dryers is delivered to the mill in railroad tank cars, from which it is discharged into a concrete receiving tank 4 x 4 ft. in cross section, under one of the switch tracks. This tank is 300 ft. long, so eight cars can be discharged into it at the same time. The bottom of the tank is sloped from both ends to the transverse center line, where the oil drops into a 12-in. pipe leading to two 38,000-barrel steel storage tanks at the edge of the shore. These tanks are in a depression, 600 ft. from the closest building of the mill, with their tops below the rim of this depression so no menace from fire is offered to the mill by them. The oil is pumped from either of these tanks by a triplex pump, gear-driven by a 15-h. p. alternating-current motor, to a 7 x 22-ft. steel pressure tank in a separate concrete building toward one end of the clinker storage space. This tank has steam-heated coils in the bottom, steam being supplied from a boiler 200 ft. distant, and is arranged so air can be pumped in on top of the oil to regulate the pressure of the latter. A 6-in. distribution main extends from the tank to various parts of the mill for supplying this fuel oil under pressure to the different buildings.

The compressed air required for various purposes around the mill is supplied from equipment in the power station which is adjacent to the finishing mill. This building contains three compressors, two of which have a capacity of 1,705 cu. ft. of free air a minute and the third of 1,207 cu. ft. per minute. These compressors supply air for operating the oil system and also for drilling in the quarry. The building also contains twelve No. 10 Sturtevant blowers that supply air blast for the cooling towers. These compressors and blowers are all belted to friction-clutch drive pulleys on a line shaft direct-connected to a 800 h. p. alternating-current continuous-speed Westinghouse induction motor. They are arranged to deliver to either of two 5 x 17-ft. receivers from which air is supplied to a distribution system. A 6-in. pipe line is also extended from these receivers to the high-lime rock quarry. A second power station, with the same equipment as this one, is being installed in connection with the second unit of the mill.

The main buildings of the mill are all steel-framed structures, having corrugated galvanized sheet-iron sides and roof. The frames are designed according to modern mill-building practice, roof trusses being used to confine the columns to the sides of the rooms into which the buildings are divided. The steel was all rolled and fabricated by the American Bridge Co. and was detailed in the San Francisco office of that company, of which office Mr. E. J. Schneider is contracting manager. The steel was erected by the Humbolt Contracting Co.

In addition to the various contractors for equipment already mentioned, W. F. Mosser & Son furnished the rotary dryers and cement kilns. The ball mills and tube mills were all built by the Allis Chalmers Co.

The operation of the mill is at all times governed by the results of analytical tests of the raw materials and clinker made by a chemist in charge of a thoroughly-equipped laboratory. The two kinds of rock are carefully tested in the ledge before blasts are fired, by taking samples from all of the drill holes. After a blast, the rock on which quarrying is in progress is also analyzed each day to determine the proper proportions of the raw materials. As a further check on the proportioning of these materials, a mechanical sample-collecting device is placed on the screw conveyor leading from the raw-grinding building to the kilns, and the rate of burning is controlled according to the results obtained from analysis of the samples thus obtained. The raw materials are so remarkably uniform in character, however, and the methods of mixing them are so through that the variations in the composition of the ground materials supplied to the kilns is very slight.

A complete physical testing laboratory is installed in which briquettes of neat cement and of 1:3 sand morter are tested under various age and seasoning conditions. Arrangements are also made for storing briquettes in water and in air so these tests can be extended over a long time. The location of the plant immediately on the shores of the Pacific Ocean suggested the importance of testing the action of sea water the cement produced, and the experiments thus far conducted in this connection unquestionably indicate that this cement is peculiarily adapted for salt-water operations. Such a result is not at all unexpected, in light of the fact that the aluminates are practically absent.

Mr. William J. Dingee is president, Dr. Irving A. Bachman, vice-president, Mr. L. F. Young, secretary, and Mr. L. H. Roseberry, superintendent of the Santa Cruz Portland Cement Co. Mr. Roseberry is general superintendent of the Dingee-Bachman interests, and has for some years given his entire attention to the design, construction and operation of their properties. Mr. F. H. Davis was the engineer in charge of the construction, and is now assistant to Mr. Roseberry in the operation of the plant. Mr. Llewellyn T. Bachman is the chief chemist.

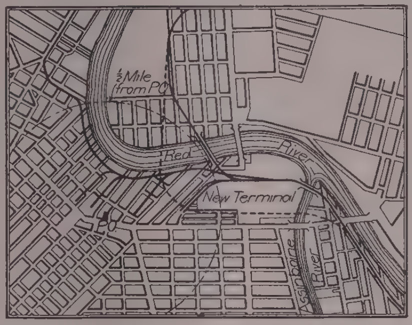
A Rapid Installation of Steam Heating Equipment was recently made in a market house at Trowbridge, England, in which some public religious meetings were to be held. The order for the work was given one Saturday at 9:45 a. m., and at 7:30 a. m. the following day the work had been completed, including the installation of a steam boiler with an independent pump for return of condensation, all necessary fittings, reducing valves, steam traps, and so forth, 1,080 ft. of cast-iron feed pipes with 40 fittings and 1,140 ft. of wrought-iron pipe with 176 fittings. The work of installation, which was accomplished by 30 men, working continuously all night, involved making 159 joints in cast-iron pipe, over 500 screw joints in the wrought-iron pipe, and the handling of over 12 tons of material. A portion of the system was completed at 4:30 a. m. on Sunday morning and steam turned into it, while steam was turned into the remainder at 7:30 a. m., but no leaks were found. It is stated that, while the temperature within the building at 7 a. m. was 36° Fahr., at 10:45 a. m. it had been raised to 60°. The notable feature of the installation was its emergency character, since lack of previous notice precluded any preparations being made.

The Fort Garry Station and Local Freight Terminal, Winnipeg, Manitoba.

By J. D. Matheson, Assistant Engineer, Warren & Wetmore, Architects, New York City.

Plans have been completed and contracts are about to be awarded for the construction of the Fort Garry passenger station and a local freight yard at Winnipeg, Manitoba, for the joint use of the Canadian Northern and the Grand Trunk Pacific Railways. The ground to be occupied by these facilities is an area of 70 acres, located within half a mile of the center of Winnipeg, bounded by the Red River on the east, the Assiniboine River on the south, Main St. on the west and Water St. on the north. The site derives its name from old Fort Garry, which was built here in 1822, to protect the trading post established by the Hudson Bay Co.

The present passenger station of the Canadian Northern Ry., which is located near the corner of Water and Main Streets, has been entirely outgrown by the rapid growth of Winnipeg, and the present freight shed is in poor condition. Adjacent to the freight house is a team yard of 150 cars capacity. An area of about 10 acres at the southeast corner of the plot is now occupied by the engine houses, car and machine shops and store houses of the Canadian Northern. A new layout of engine and car facilities to replace these has already been constructed at the general yards of the railway company, one mile west of Main St. The railway companies have acquired at a large outlay the balance of the property within the area above described, with the exception of a few lots fronting on Main St. As the area is at present bisected by Broadway, leading to the Broadway Bridge over the Red River, it was evident that the property could never be developed for railway terminal purposes, unless Broadway was closed between Main St. and the river. This the city authorities were unwilling to do, owing to the fact that the Broadway Bridge was recently constructed to accommodate vehicular and pedestrian traffic between Winnipeg and the town of St. Boniface, a rapidly developing community on the other side of the Red River. A compromise agreement was reached between the city and the railway companies allowing the location of the passenger station and office building on Main St. opposite Broadway, thus closing the street; in consideration of which the railway companies must provide street connections between the east end of Water St. and the Broadway Bridge. It had previously been the intention of the company to locate the new station building at the corner of Main and Water Streets, on practically the same site as the present station, which would be somewhat more convenient, because closer to the center of the business district at Portage Ave. and Main St.



Location of New Terminal.

The designers of the proposed terminal were instructed that they might disregard all existing facilities, including even the river bridges, and design a layout, using the total acquired area of property as noted above for a passenger yard, train shed, local delivery yard and freight houses, having a maximum capacity and offering the greatest advantage from the standpoint of operation and convenience to the public. The only predetermined feature was the location of the station building opposite Broadway.

The Canadian Northern Ry. commenced operation in 1896, with about 100 miles of line. There are now 3,800 miles in operation and the lines are being rapidly extended. The traffic is increasing at such a rate that the past records of traffic handled were of little use in determining the probable future business to be provided for. The Grand Trunk Pacific Ry. being an entirely new road, mostly through new and undeveloped country and not at present in operation, offered no means of determining the requisite capacity, other than forecasts of the probable new business to be developed. It was at first intended to have the terminal site provide for the passenger coach yards and engine houses of both companies. After several alternate layouts had been made, it became evident that an ideal layout for the passenger yard, trainshed and the local freight delivery yards and freight houses, of a capacity which was estimated would be required in the near future, could be made only by devoting the entire area to these purposes. Accordingly, the Canadian Northern Ry. has provided for its engine and coach facilities at the general freight yard, one mile west of Main St., in conjunction with its car and machine shops and storehouses. The Grand Trunk Pacific Ry. has likewise provided similar facilities at its general yard now under construction, about 3 miles east of the new terminal.

The first design contemplated a stub-end passenger station using a wye track across the Red River at St. Boniface and backing all trains across a new bridge over the Red River and into the station. The latter was laid out at an angle of about 45 deg. with Main St., the local freight yard and freight houses being between the trainshed and Water St. Using the same type of stub-end terminal, an alternate layout was made having the trainshed parallel to Main St., with the local delivery yard and freight houses adjacent to and reached by driveways from Water St. In this case the wye would be located directly south of the station, and therefore necessitate bridges over both the Red and Assiniboine rivers on the same straight line. The use of a wye on the St. Boniface side would have required the abandoning of the present main line of the Canadian Northern Ry., about a mile west of Main St., crossing the Red River on a new bridge at that point and using an entirely new main line connecting with the present main, about 1½ miles east of the terminal. The advantages of this type of terminal were its avoidance of grade crossing of streets near the terminal, the suitability to the severe winter climate of Winnipeg, since the trainshed would be enclosed on three sides, and the accessibility of the platforms from the passenger concourse. These advantages were offset, however, by the fact that the distance between the wye and the terminal would be at least half a mile, thereby rendering impossible the efficient operation and dispatch of trains during busy periods and the necessary increase in running time of through trains due to this long back-up. These reasons led to the adoption of the through station type of terminal, as shown in the plan herewith, which is believed to include all of the advantages claimed for the stub-end terminal, and at the same time to afford efficient operation for both through and local trains.

Passenger Station.—In the through station layout, which has been finally adopted, the approach tracks are elevated over the intersecting streets, and are sufficiently above the main floor of the station to allow a passenger entrance subway beneath. There are eight through passenger tracks with adjacent platforms and two separate open-running tracks at the rear for through freight trains. The platforms are 20 ft. wide and can be made 1,650 ft. in length. By means of this great length and the use of the double crossovers, as shown, each track is capable of handling two trains of 11 cars each during periods of heavy traffic. The total capacity of the platforms will be two hundred 70-ft. cars. The platforms will be of reinforced-concrete raised 12 in. above the base of rail. Between each pair of tracks there will be three lines of pipe for water, steam and gas.

Passengers going to trains pass from the rear of the ticket lobby, which is on the level of Main St., into a subway 50 ft. wide with 10-ft. headroom, having 7-ft. stairways on each side leading up to each platform. The subway is so arranged by means of railings and gates that there will be no interference between passengers going to trains with those coming from trains. The elevation of tracks will be 10 ft. above the level of the main floor of the station, and a slight ramp down from the rear of the ticket lobby to the floor of the subway allows the clear headroom of 10 ft.

For the present the baggage and express business will be handled in the south wing of the station building, but at some time in the future these facilities will occupy space beneath the tracks, which will be carried by steel viaduct construction. The south wing of the station will then contain a baggage checking counter for the convenience of passengers, with pneumatic tube connections with the baggage room, and the remaining space can be used for an additional waiting room and for offices. All of the sheds beneath the tracks will have a clear headroom of 10 ft. They will be approached from a 50-ft. driveway, 3 ft. 6 in. below the floor of the sheds, reached by a 4 per cent. grade down from Main St., immediately south of the station building. On the south side of the driveway will be the express sheds, one for each road, with an available floor space of 15,000 sq. ft. in each shed. On the north side will be the baggage room with an available floor space of 20,000 sq. ft. and a mail room with an area of 10,000 sq. ft. On both sides of the drive there will be a row of electric elevators, one to each platform. To supply the eastbound trains at points north of the station building, a 15-ft. trucking subway runs parallel with the tracks on the outside of the passenger trainshed to a cross subway, likewise provided with elevators to each platform. By these arrangements there will be no necessity of trucking of any kind on the platforms, thereby affording the passengers the unobstructed use of same. This system of handling baggage, express and mail beneath the tracks, with elevators to each platform, is similar to that now in successful operation at some of the largest passenger terminals in the United States and Europe.

The west approach to the passenger tracks at the station will start from the present main track on the north bank of the Red River, about 2,000 ft. west of Main St., and ascending on an earth embankment at a maximum ruling gradient of 0.4 per cent. will pass over Main St. on a double-track plate girder bridge, allowing an under-clearance of 14 ft. for the street. It will then cross the Assiniboine River on a new double-track steel truss bridge 400 ft. in length, one span of which will be a swing bridge, in accordance with Government requirements. The east approach starts from the present main line at the St. Boniface station and rises on an earth embankment with the same gradient as above to the Red River, which it crosses on a new double-track steel truss bridge 900 ft. in length, containing one draw span. It then crosses on a steel plate girder bridge the Winnipeg Transfer Ry., Mill St., Notre Dame Ave. and Water St. The proposed base of rail will be practically level from the Red River bridge to the Assiniboine River bridge at elevation 766, which is approximately 10 ft. above the level of Main St.

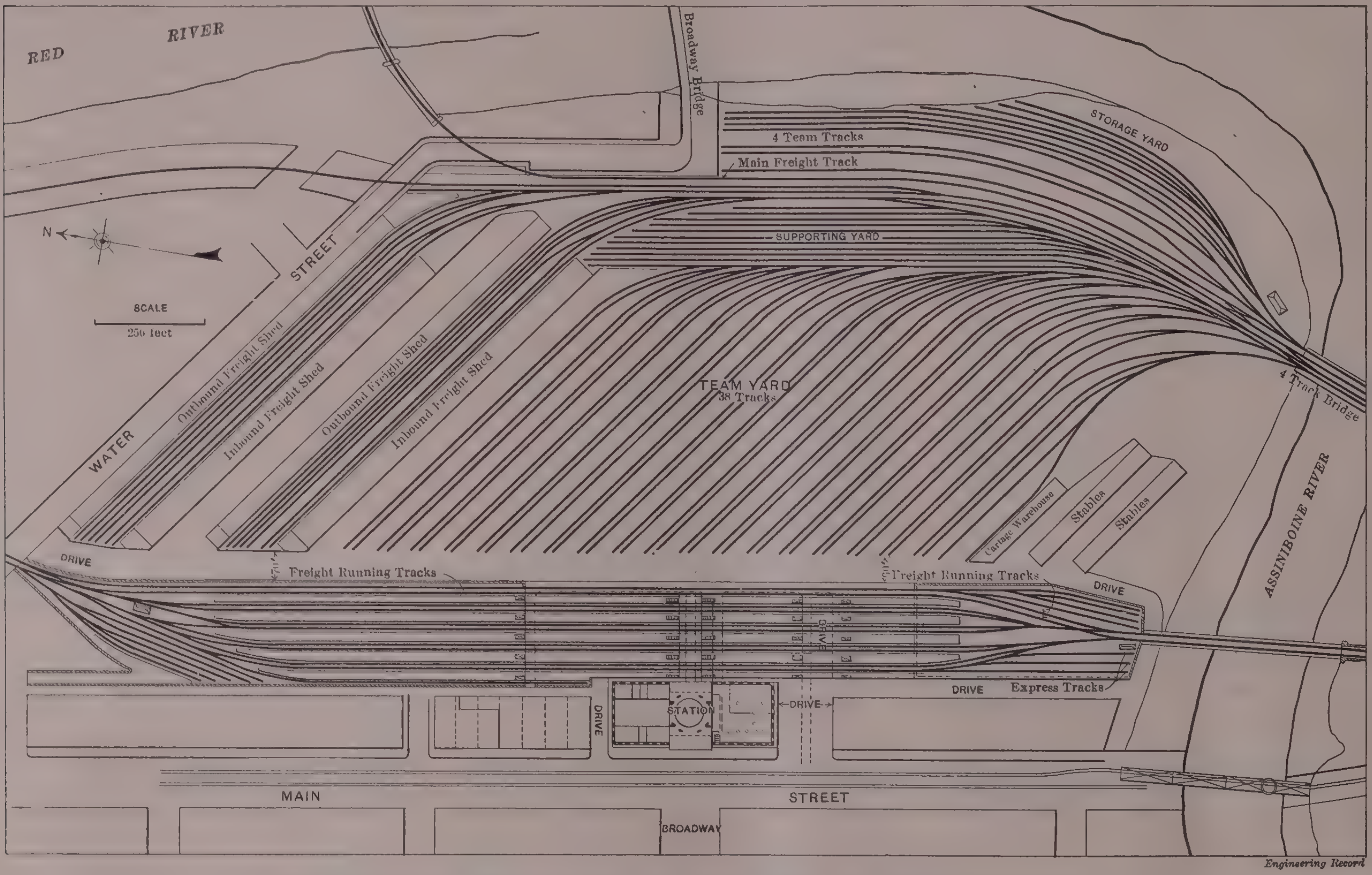
At each end of the passenger layout there will be a signal tower controlling all switches by the electro-pneumatic system. All track work will be of first-class construction, with 80-lb. rails and gravel ballast.

Station Building.—The station building will be an imposing structure, built entirely of stone, having a length of 350 ft. along Main St. and a width of 140 ft. The height of the larger portion of the building will be 3 stories and basement, with an elaborate central portion surmounted by a dome rising 100 ft. above the street level. The main entrance will be off Main St. at the center of the building. The main floor is at street level and will be devoted entirely to station facilities, and its arrangement is considered exceptionally good for convenience to passengers and facility of operation.

Passengers going through the main entrance pass through a vestibule and arrive directly in the ticket lobby, which is a clear circular space 90 ft. in diameter, entirely unobstructed by columns, seats or booths of any kind. This lobby is directly beneath the dome and will be exceptionally well lighted on all four sides by large arched windows. On the east and west sides these windows open through to the front and rear walls of the building and on the north and south sides to the large open courts. The ticket booths are arranged on the south side of the lobby, and passengers after purchasing tickets go directly to the baggage checking counter at the rear of the booths. They may then pass out from the lobby through the rear vestibule to the subway under the tracks, from which stairways lead up to the platforms overhead. On the north side of the ticket lobby spaces are provided in each corner for telephone and telegraph booths and newspaper and book stands.

The waiting room lies north of the ticket lobby, this arrangement being adopted so as to secure a quiet waiting room, as all passengers going to and from trains may pass directly through the unobstructed lobby without entering the waiting room.

Adjoining the waiting room on the west side facing Main St. are a lunch room and a restaurant, both of which have separate entrances off of Main St., for handling the local business direct. A carriage entrance is located at the north end.

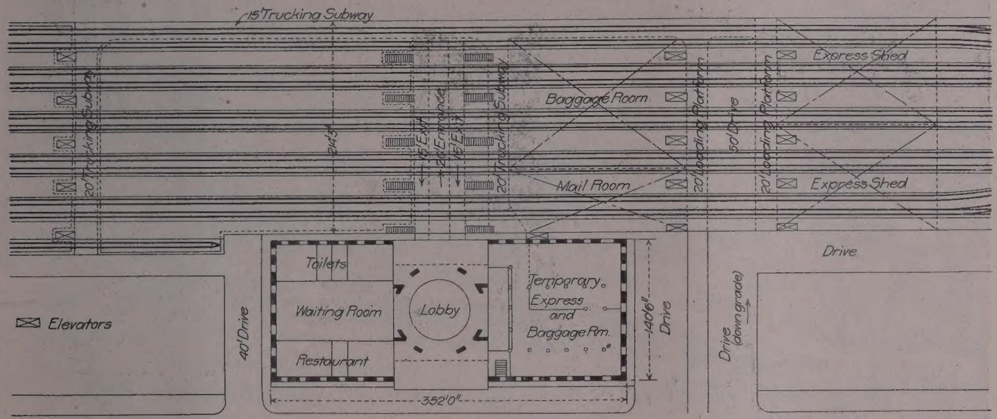


Plan of Fort Garry Passenger Station and Local Freight Yard, Winnipeg, Manitoba.

The central portion of the waiting room is covered over by an arched skylight, 40 x 100 ft., over which there is an open court, thus providing the waiting room with excellent light. The seats will be heavy oak benches of the movable type. The interior of the waiting room and the ticket lobby will have the effect of stone construction throughout, the wainscoting being of marble 6 ft. high and the floors of terrazzo. All stairways will be of iron with marble treads.

For the present the entire south wing of the main floor will be occupied by the baggage and express rooms. In the future, when more space is required, both the baggage and express will occupy space beneath the tracks and platforms as above described. A driveway for baggage and express wagons is provided at the south end of the building, 3 ft. 6 in. below the level of the main floor. It is reached by a short 5 per cent. grade down from Main St., and the wagons are loaded and unloaded on an 8-ft. platform outside the building wall. The baggage and express will be handled by hand trucks between the building and the train platforms, using the trucking subway and the elevators above described.

The entire north wing of the basement, the floor of which is 15 ft. below the level of Main St., is devoted to immigrants. There is a waiting room with an area of 10,000 sq. ft., a laundry and toilet and bath facilities for men and for women. The basement can be reached from the waiting room, from the trains or from Main St. by separate stairways.



Passenger Stations, and Arrangements for Handling Passengers, Baggage and Express.

The second and third floors will be occupied by the offices of the two railways and by the National Transcontinental Ry. These offices are on either side of the corridor, the interior row of offices in each wing facing on the open court. Each floor provides an available office space of 25,000 sq. ft., exclusive of corridors, stairways, elevators and toilets. Provision has been made in the design of foundations and the steel structure of the building for the future addition of six office floors, so that the building will then be capable of providing 200,000 sq. ft. of office room. The building is so designed that there will be no necessity of artificial lighting in any portion of the day. The heating will be done by steam, indirect system, with mechanical ventilation. The column loads will be supported at the foundations by Raymond concrete piles, this being necessary on account of the heavy column loads and the character of the blue clay underlying the city.

Local Freight Terminal.—The problem of obtaining a layout for local freight delivery yards and freight sheds, which would give sufficiently large team track capacity, long freight sheds and equal facilities for both roads, which would allow great accessibility for teaming, and could be properly worked by switching, was complicated by the peculiar shape and conditions of the ground, and by the fact that the throat of the yard had to be located on a bridge across the Assiniboine River. The plan finally adopted gives the greatest car capacity, as well as the greatest facility of operation and access to teams of several tentative layouts which were drawn up and studied.

The team yard contains 42 tracks of the total capacity of eight hundred and thirty 40-ft. freight cars. The switching leads to the team yards are divided by crossovers into three separate portions, each controlling 14 tracks, so that three switching engines may be worked at the same time. The usual length of team tracks is 800 ft. with a capacity of 20 cars each. The team driveways will be of stone block construction on a 6-in. concrete base. This construction is made necessary by the treacherous character of the clay soil, which when wet, will heave and swell, causing an ordinary light pavement to break and disintegrate. The driveways are 30 ft. wide between curbs, the tracks being on 40-ft. centers across the driveway. Adjacent pairs of team tracks are on 12-ft. centers. Tapping the ends of these driveways is a paved avenue from 60 to 70 ft. wide, running the full length of the yard. This avenue is accessible from Water St. on the north, passing beneath the bridge carrying the east approach overhead, and from Main St. near the Norwood Bridge on the south, passing beneath the south approach. The surface drainage from all the driveways will be by means of gutters on each side of each driveway, ending at catch basins, located at the ends of the driveways on the east side of the wide avenue. These catch basins discharge into a vitrified line of tile pipe running beneath the drive and discharging into the Assiniboine River.

The freight shed facilities consist of two inbound and two outbound sheds, one set for each road. The outbound sheds are 40 ft. wide and 1,000 ft. long, each served by four tracks. The inbound sheds are 50 ft. wide and 900 ft. long, each served by two tracks. Between these inbound and outbound tracks are 10-ft. transfer trucking platforms. Each road will therefore have a freight-shed track capacity of one hundred and forty-four 40-ft. cars. The freight sheds will be one story high, with steel columns and roof trusses and sliding doors on both the track and team sides, so that any portion of the shed may be opened.

The freight offices will be located above the ends of the sheds and connected by a bridge 40 ft. wide, spanning the intermediate tracks and connecting the outbound and inbound sheds. The freight agent's office will be located in this bridge, where he can view the loading and unloading of cars.

The switching leads to the freight sheds are of such length that the tracks may be switched without the engine having to cross the bridge at the throat of the yard. The supporting yard has a total capacity of 385 cars. This yard is for the reception and storage of arriving trains of loaded cars to be switched into the team tracks, and for departing trains of empty cars which have been switched out from the team tracks. A connection will be maintained with the present Winnipeg Transfer Ry. track, along which are located numerous industrial sidings and over which cars for transfer with the Canadian Pacific Ry. are handled. This connection will pass beneath the east approach of passenger tracks near Lombard Ave. The present main track crosses Assiniboine River on a wooden draw bridge, which will be replaced in the new scheme by a steel 4-track bascule bridge having two separately operated leaves. The Red River is crossed by the present main track on a comparatively new steel truss bridge. This bridge will be maintained for the proposed new layout and used mostly by the Grand Trunk Pacific Ry. trains for local freight running between this terminal and the general freight yard located about 3 miles east. The adjacent shore span will need to be reconstructed to meet the change in alignment of the running track. This track will pass over the east end of Water St. on a plate girder bridge, the street being somewhat depressed for this purpose. The driveway across the Broadway Bridge over the Red River will be maintained as at present. The west approach to the freight yard will use the same line and be at street grade the same as the present main track. The length of all switching leads for each part of the freight yard is such that no switching whatever will be done across Main St. The only traffic across this street will be that of trains of local freight between this terminal and the Canadian Northern Ry. general freight yard, one mile west. All the through freight trains for both roads will be run on the proposed new overhead line, passing around to the rear of the train shed on the two open running tracks.

At the north end of the new Assiniboine River freight bridge there will be located a signal tower, from which will be controlled by electro-pneumatic interlocking, all the signals, switches and crossovers of the tracks entering the bridge. The sharpest curves used in the layout are 14 deg., 410 ft. radius. The frogs used are mostly No. 7 with No. 10 for main track connections and main crossovers. The track construction in the freight yards will have 60-lb. rails and gravel ballast. As each railway company will have its own cartage company to handle all trucking from the freight sheds, as well as a large amount from the team yards, there will be provided, adjacent to the team yard, a warehouse and two stable buildings, each of the latter to accommodate 200 horses. Each of the joint railways will use its own passenger coach yard, engine houses and shops, in conjunction with this terminal.

Due to the inevitable future development of the great northwest territory of Canada, Winnipeg, will in time, it is predicted, occupy the same important position as the railway center of Canada, that Chicago now occupies as the railway center of the United States. The officials of the joint railways and the architects have made this fact the leading consideration in the layout and design of both passenger and freight terminals. The plans have been so drawn that the above scheme of operation may be realized in the future development, though the initial construction will involve only that portion necessary to handle the traffic presented by the requirements of the present and of the immediate future.

The railway officials who co-operated for the construction of these joint terminals, and who personally rendered valuable assistance in the work of design, are: Canadian Northern Ry., Mr. Wm. Mackenzie, president; Mr. D. D. Mann, vice-president, and Mr. M. H. MacLeod, general manager and chief engineer. Grand Trunk Pacific Ry.: Mr. Chas. M. Hays, president; Mr. F. W. Morse, vice-president and general manager, and Mr. B. B. Kelliher, chief engineer. Warren & Wetmore, architects, New York City, had charge of the design of both the station building and the yards and will supervise the construction. Mr. A. R. Whaley, manager of the Grand Central Terminal of the New York Central & Hudson River R. R., New York City, was consulted in regard to the practical operating features of the track layout. The engineering features were in direct charge of the writer as assistant engineer.

The Concrete Mixer Cars of the Chicago Railways Company.

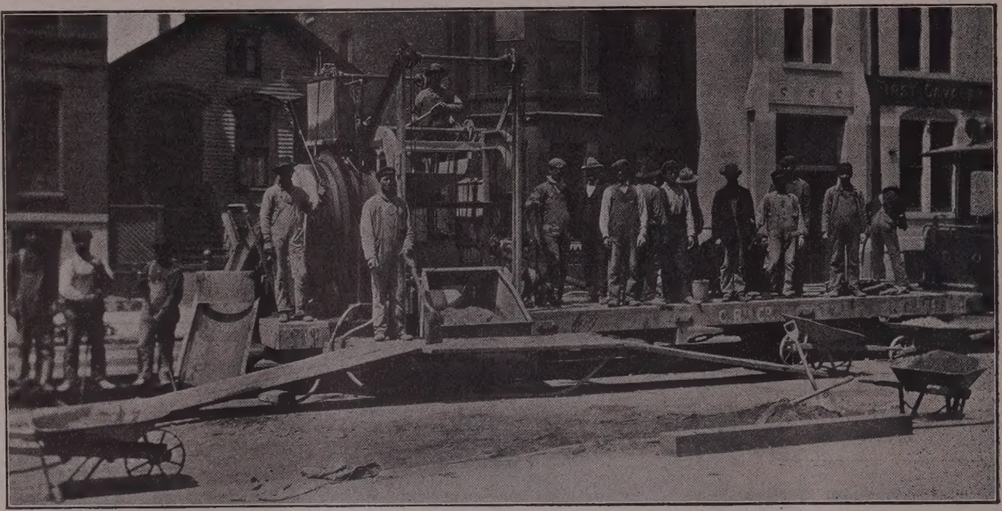
The ordinance requiring the rehabilitation of the entire systems of the various street railways in Chicago was not formerly accepted by the Chicago Railways Company until last February. This company had, however, done some reconstruction work last year, complying with the standards specified by the board of supervising engineers formed under the ordinance governing the work, in anticipation of the acceptance of this ordinance, but the amount of work to be done by the company this season is very much greater than what it undertook a year ago. A complete description of the rehabilitation plans, including the conditions governing them and the methods of construction followed in the work done last season, was printed in The Engineering Record of October 19, 1907. This previous work is quite similar to that being handled by the Chicago Railways Company, but the latter has recently installed two newly-arranged concrete mixer cars, which are used in mixing and placing the heavy concrete sub-base on which the tracks are laid.

This sub-base concrete is mixed wet in the proportions of 1 part cement, 3 parts sand and 6 parts broken stone, and is thoroughly tamped in place, both hand and machine mixing being employed. In cases where the concrete is mixed by hand, two portable platforms are placed on the rails of the new tracks, the latter being laid and blocked up in position in advance of the concrete work. Each platform is manned by six laborers, and the concrete is dropped from the end of it uniformly across the width of the excavation. Two of these mixing outfits working under favorable conditions can build the sub-base for 500 lin. ft. of track a day. They are generally started about 250 ft. apart in the morning, and at the end of the day the rear board has been worked forward to the point where the forward board started.

The machine mixers were designed and built especially for this purpose by the Chicago Concrete Machinery Co. A Chicago concrete mixer with a capacity of 1/3 cu. yd. is mounted on one end of a low flat car that is operated on the temporarily supported track, in advance of the work on the concrete base, by an old motor car. An elevator frame for two charging skips is erected across the car in the rear of the mixer, with one skip operating on each side of the car. The sand and stone are distributed in piles along the curb and are loaded into wheel barrows from these piles by hand. The loaded wheel bars are pushed up an incline mounted along one side of the car carrying the mixer and are dumped into the charging skip bucket on that side from a platform only 2 ft. above the level of the street.

The charging buckets are designed to hold 13 cu. ft., which is just the proper volume of materials for one batch in the mixer. They are each fitted with guide rollers working in a track made of steel channels that forms a part of the frame supporting the feed spout of the mixer. The buckets are hoisted by a cable working over a sheave on top of a frame carrying the runway, which frame automatically guides and tips the bucket as the latter reaches the top of it, discharging the contents of the bucket into the feed spout of the mixer. Each skip bucket has its individual hoisting drum, friction clutches and brakes, so that it may be controlled independently of the other. A safety stop also automatically disengages the hoist clutches when the skip bucket reaches its extreme height. As a bucket and hoist is mounted on each side of the car, the latter can be worked on either of two tracks while the other track is open for traffic. When the machine is working on one track and the other track is in service, the inside skip is removed so as to give proper clearance for passing cars. The height of the framework of the mixer and bucket hoist has been kept down to a minimum in order to enable the car to be run under overhead railroad crossings and other structures. With the skip buckets removed the mixing equipment is also no wider than a standard street car. The car shown in the accompanying illustration is one of the first to be built; a four-wheel car placed in service recently is just long enough to mount the mixer and the elevator frame in the rear of the latter.

A man to operate the hoist and one to attend to the discharge spout, the latter also handling an automatic water-measuring tank, are the only men required on the mixer car. The capacity of each car is said to be between 50 and 60 batches an hour, or a total of 150 cu. yd. of concrete per 8-hr. day. As the amount of concrete required to be laid averages about 1,650 cu. yd. per mile of track, the machine can cover from 500 to 600 linear feet in a day.



A Concrete Mixer Car of the Chicago Railways Company.

The track reconstruction is under the direction of representatives of the board of supervising engineers, as was outlined in the previous description, Mr. R. F. Telker, Jr., being division engineer of that board in charge of the general track reconstruction of the Chicago Railways Co. Mr. J. H. Powers, division engineer of that company, is in charge of the actual construction work under the direction of Mr. C. A. Call, general roadmaster of the company.

A Water-Cooling Tower of Unusual Form has recently been built at the power station of the Central London Ry., London, England, consisting of a brick building, 30 x 79 ft. in plan and 40 ft. high, with a reinforced-concrete roof, from the middle of which rises a brick chimney of 24 ft., internal diameter, to a height of 75 ft. above the roof, or 115 ft. above the foundation of the building. The lower rectangular portion has large air-inlet openings entirely surrounding its base, and contains within, a water-distributing system of wood, consisting of cooling hurdles over which the hot water is spread by falling from distributing pipes on splash plates. There are 20 hurdles, which consist of triangular strips laid in frames, and so arranged as not to baffle the rising air currents. The total fall of the water is 26 ft.

The Proposed River Training Wall at Rangoon, India.

The Rangoon Port Trust, a commission having charge of the improvements of the Port of Rangoon, Province of Burma, India, has prepared plans and is ready to start work on a training wall 2½ miles in length, built in water having a depth of 20 to 100 ft. at low tide, in order to confine the flow of the river in such a way as to maintain a minimum depth at a number of import wharves of 27 ft. below the low spring tides.

The Port of Rangoon is the third in importance in India and has a total shipping of 4,500,000 tons a year, of which 2,250,000 tons is rice for export. As the wharf facilities had for many years been growing inadequate, about seven years ago the government determined to build a system of import wharves, it being deemed inadvisable to attempt to provide dockage facilities for both import and export trade. Accordingly all goods for export are put aboard sea-going vessels by means of lighters, the vessels themselves lying at anchor in the open river.

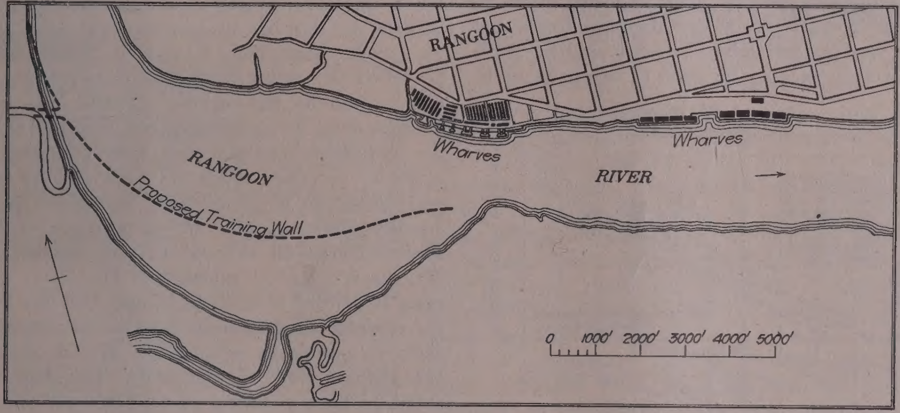
The wharves are each built on seven rows of solid rolled-steel piles, 7 in. in diameter, with 4-ft. 6-in. screws. The piles have an average length of 70 ft., with a maximum length of 90 ft.; they are braced together at the top and covered with a reinforced-concrete deck. The cargo is handled by means of hydraulic cranes, each capable of raising 3,500 lb. to a height of 70 ft. with a radius of gib of 42 ft. The improvements represented an expenditure of $5,000,000, and were formally opened by the Viceroy last November.

The completion of these large works has called attention to the erosive action of the Rangoon River which has been going on for the last twenty-five years. Heretofore its effects have not been such as to cause an alarming silting-up on the bank of the river on which the city is situated. The evidence of such action, however, is so conclusive that it is quite certain that in time the maintenance of the proper depth at the new wharves would be a serious and constant problem. To avoid this result by confining the river to a narrower channel and thus cause it to scour its bed to the desired depth, is the purpose of the training wall which has been projected.

Just opposite the city the current has eroded a considerable bend having a width of over a mile, while the width between banks both above and below the bend is about 2,000 ft. The training wall will start upstream at the point where the erosion first becomes noticeable, and at the maximum width of the river will be about 3,400 ft. from the left bank, on which the city is situated, and 2,000 ft. from the right bank. The depth of the river along the latter bank varies from 40 to

100 ft. at low tide, the tidal rise being 20 ft. The total length of the wall will be 2½ miles, and the area between it and the eroded bank will be filled with sand and mud pumped from the bed of the river.

In constructing the wall, it is proposed to put down a bamboo mattress, 300 ft. wide, as a foundation, and deposit on it granite rock, which will be carried up on a slope of about 1½ to 1 until above the level of the water. The stone is obtained from a quarry about 130 miles distant and is loaded into sea-going bottom-dump boats having a capacity of 1,000 tons each. The quarry from which this stone is obtained is being developed by a system of Lidgerwood cableways. The mattresses will be held in line by dolphins 250 ft. apart. After the mattresses are sunk the placing of stone will be a simple matter with the use of the bottom-dump boats. Since the tidal current travels between 4 and 6 knots, and is reversed, of course, with every change in the tide, a rather serious problem may be presented by the tide backing up between the wall and the eroded bank while construction is in progress. It is expected that the entire proposition will cost about $7,000,000, of which amount $1,500,000 has been contributed by the Imperial Government.



Rangoon River, Showing Location of Proposed Training Wall.

In connection with the proposed work, a sand pumping dredge of very large size has been built for the Port Trust by William Simons & Co., Ltd., on the Clyde. This dredge is designed to pump 3,000 cu. yd. of sand per hour, from a depth of 55 ft., through a floating 42-in. pipe line, with a maximum length of 5,000 ft. The vessel is sea-going and will proceed to India under her own steam. Both the propelling engines and those driving the centrifugal pumps are of the triple-expansion condensing type. All of the signaling devices, gauges and levers for controlling both propelling and pumping engines, the winches at the bow and at the stern are placed in a house above the top canvas-covered deck so that all operations can be controlled by one man, whose position allows him to have full sweep of the pipe lines and the mooring chains. The dredge cost $350,000, and about $400,000 more will be expended on the development of the quarry, the bottom-dump stone boats, and other construction plant.

The plans for the new training wall and the wharf facilities were prepared by Mr. George C. Buchanan, chairman and chief engineer of the Rangoon Port Trust. The plans for the training wall were submitted to Dr. E. L. Corthell, who approved them.

A SUBMARINE VESSEL has recently been built in France for sponge fishing, which is said to have proved successful in trial manœuvers. It has a cylindrical steel shell about 16 ft. long by 5 ft. in diameter, and with rounded ends. This shell is not equipped with propelling machinery, but is manipulated from a tender and only fitted with submarine lamps and sponge grapples.

Transportation of Ashes and Rubbish in Philadelphia.

The removal of ashes and rubbish at night from the downtown districts of Philadelphia by means of cars operated on the street railway tracks has been inaugurated recently. The contractor for the collection of the city's refuse has arranged with the Philadelphia Rapid Transit Co. for the transportation of the refuse collected in the section of the city between the Delaware and Schuylkill rivers, and bounded on the north by Poplar St. and South St. on the south, the price to be paid for this service being $10,000 per month. The territory to be initially served covers an area of approximately four square miles, but it is proposed to extend this method of refuse handling to other districts in case it proves more economical than the present horse-drawn wagons.

A single receiving station has been established on a plot 150 ft. square on Wood St., between Broad and 15th Streets, in the central portion of the district to which the collection carts bring the refuse to be dumped into cars. The station building contains an elevated floor, which the collection wagons reach by means of a ramp with the assistance of a motor-driven winch. On this floor the wagons dump their loads onto an inclined surface covered with plate-steel that delivers the material directly into the hopper cars standing on tracks on the surface below. The volume of refuse removed daily varies considerably, ranging from 700 to 1,000 cu. yd. per night.

For the transportation of this material eight special cars have been built by the Philadelphia Rapid Transit Co., each of which has a capacity of from 32 to 35 cu. yd. The bodies are about 35 ft. in length and have sides about 7 ft. high, with V-shaped bottoms for gravity dumping. This method of dumping the loads was thought preferable to the one employed in connection with a similar system in operation in Brooklyn, N. Y., where the material is transported in large buckets, which necessitate hoisting apparatus to handle them. The sides of the cars are formed of four pairs of double side-swinging doors held at both top and bottom by catches that are released for dumping by gang levers. The cars are built of wood, but are lined with steel where in contact with the refuse material. They are each mounted on two trucks, and are operated by four 75-h.-p. railway motors.

The material is transported about 5 miles for dumping on the site of the new Torresdale Boulevard that is under construction in the northern part of the city, and on low lands and in hollows adjoining it. Temporary trestles, fitted with bracket trolley, are built over the dumps, and the cars discharge their contents by gravity over the sides, the trestles being extended as the fills are advanced. The cars usually travel in pairs at about 30-min. intervals, the first leaving the receiving station at 7:30 p. m. The cars are kept in service from 8 to 12 hr. per night, each car averaging from four to five round trips.

The Proposed Auxiliary Fire-Protection System for San Francisco.

Plans for an auxiliary high-pressure fire-protection system for San Francisco were submitted to the board of public works of that city some months ago, but funds for the construction of this system have not been obtainable until the recent favorable local election on an issue of bonds to cover the cost of it and of various other extensive improvements. The system, estimated to involve the expenditure of $5,500,000, contemplates providing water under sufficient pressure to preclude the necessity of portable fire steamers. Under normal conditions, it is proposed to pump fresh instead of salt water through the mains, but for great emergencies an additional protection system is to be provided by auxiliary stations and fire boats which will pump salt water.

The protected area lies on the easterly watershed of the peninsular on which the city is located and includes the entire present fire limits, together with nearly all of the district in which shingle roofs are prohibited. In extent it covers 5,300 acres, or about 8.2 sq. miles, which is nearly double the area of the burned district. The protected area is to be divided into two zones; the lower zone will include those portions of the area less than 150 ft. in elevation and is 6 sq. miles in extent. This zone will be supplied from a 1,000,000-gal. concrete distributing reservoir, located at an elevation of 329 ft. As the congested-value district and the greater portion of the manufacturing and mercantile industries are included in this zone the latter is to be girded by 14 and 18-in. mains, which will be cross-connected at frequent intervals in both directions with 12 and 14-in. mains. The upper zone will include that portion of the protected area that is at an elevation of more than 150 ft. and will in itself cover 2¼ sq. miles. It will be supplied directly from a 500,000-gal. distributing reservoir, to be located at an elevation of about 490 ft. Water will be delivered to each of the zones from their respective reservoirs under a pressure up to 150 lb. per square inch. Two 5,000,000-gal. storage reservoirs will be built on top of a hill, giving them an elevation of 755 ft., and will be connected by two lines of 20-in. pipe with the distribution system of mains and with the two distributing reservoirs.

Frech water for the auxiliary system will be obtained from a number of wells sunk in streets in the vicinity of two widely separated pumping stations. Each of the latter is to have equipment with a capacity of 1,050 gal. per minute, or 1,500,000 gal. per day, and will deliver to the distribution reservoirs through the pipes of the distributing system, a 175,000-gal. cistern being provided at each station. To guard against emergencies two pumping stations are to be provided on the waterfront to deliver salt water to the distribution mains. Two large fire boats are also included in the plans, and are to be equipped so they may be used independently, or may be connected with the distributing system. The salt-water pumping stations are entirely isolated from each other and are each designed for an ultimate capacity of 16,000 gal. per minute, pumping machinery having a capacity of 10,000 gal. per minute to be installed at first.

The adoption of steam-driven pumps in the auxiliary stations in preference to gasoline engines is recommended by the report on the basis that suitable fuel may be stored with greater safety, that the mechanical equipment is simpler, and more reliable, and that men competent to operate such a steam plant are always available at a moment's notice. Multi-stage turbine pumps were considered best adapted for the service in plants of both types, being directly connected to the steam turbines in the steam plant and rope-driven in the internal-combustion engine plant.

The distribution mains will be of cast iron and will be buried about 5 ft. under ground. These mains, together with the entire system, will be constructed on the unit plan, so in case any portion of the system is put out of commission by an earthquake or other cause, the remainder would not be affected. In fact, the report states that with the precautions which are thus provided against damage by earthquakes, the system may be relied upon to offer a greater resistance to destruction than the majority of the buildings which it is designed to protect.

It is believed that the proposed system will meet all the requirements of the city for a number of years to come, but provisions are made for future extensions, without adding greatly to the cost of the original system. The capacity of each of the main pumping stations may be increased 6,000 gal. per minute, additional distributing reservoirs may be constructed and fire mains may easily be laid without reconstructing any part of the system recommended by the report.

The plans for the system were prepared under the direction of the board of public works and of Mr. Marsden Manson, city engineer, by Messrs. H. D. H. Connick and T. W. Ransom.

Letters to the Editor.

Estimate Curves for Manholes.

Sir: I enclose a small tracing of some curves I have prepared, which may be of some interest to your readers who are called upon from time to time to make estimates on manhole construction. These curves afford a ready method of making estimates, and at the same time are easily corrected to meet local conditions.

To use curves, the depth of the manhole being given, follow the vertical line until it intersects with the brick curve, then read on the horizontal line to the left the number of brick required. To get the amount of sand, mortar or cement, follow the vertical lines from the intersection of these curves with the same horizontal line used in ascertaining number of brick, and read the cubic yards of sand or mortar or barrels of cement at the top. For the cost of the manhole complete + 15 per cent., follow the vertical line from the bottom to its intersection with the cost curve, then read the cost to the right. The same proceeding is followed for cost of labor, only using labor curve. The curves are for a 4-ft. manhole with 8-in. walls for 12 ft. and then 12 in. The mortar is mixed one part of cement packed and three parts of sand loose.

Yours truly,

John Wilson.

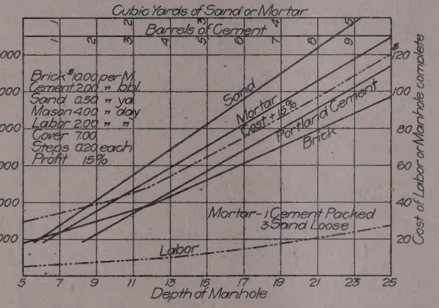
Minneapolis, Minn.

Fast Railway Location.

Sir: A locating party started out for the Grand Trunk Pacific Ry. on July 3, 1906, to locate a line from Brandon, Man., to Regina, Sask., and made what I believe to be a record-breaking run, considering the distance and country.

We were in mostly open prairie country, as there was only about seven miles of "bush" through which we passed. Our greatest difficulty was in finding good east and west trails for the camp outfit to travel while moving camp, as most of the trails run north and south to the railroads. The water was very poor and the country very thinly settled, making it difficult to get wood for fuel, and as the field party made such good progress we were compelled to move camp mostly every day. The party was made up of Mr. C. J. Seymour, locating engineer, a transitman, a leveler, a topographer, two draftsmen and fifteen others. The equipment was as follows: Three sleeping tents, one cook tent and one stable tent, three teams, one wagon with box, one wagon with hay rack, one spring wagon for field party and one saddle pony. The three teamsters, cook, cookee and draftsmen moved camp, thereby not interfering with the progress of the field party. Supplies were ordered shipped to some town on the Canadian Pacific Ry. about one week ahead and were received about every three weeks, driving from 15 to 50 miles for them. We had an excellent cook and supplies were plentiful.

Leaving Brandon, the country was mostly under cultivation until we neared the Pipestone Creek, and we had nothing much to contend with until we reached that point where we finally crossed the creek with a 65-ft. trestle, 1,300 ft. long, using maximum grades of 0.4 per cent, eastbound and 0.6 per cent. westbound. After leaving the Pipestone we ran a 34-mile tangent through a very nice prairie country until we came to the Moose Mountains, where we spent a week on six miles of line getting down, then another tangent of 18 miles, where we came to Moose Mountain Creek, where we spent several days trying to get a narrow crossing. We finally crossed with a 220-ft. bridge 1,800 ft. long, thence to within one mile of Regina with a 74-mile tangent through rolling prairie country, then returned with an alternative location to Moose Mountain Creek, and taking land ties through to Brandon, arriving there Nov. 3, after running 483 miles of line in 84 working days as follows: 218 miles of location, 90 miles alternative location and 175 miles of preliminary, making a daily average of 5.75 miles. In the month of September we located 183.48 miles in 22 days, an average of 8.34 miles per day, the big day's run being 12.46 miles location in 8 hr. 2 min. on Oct. 10, it being an ideal day for fast work, as it was cloudy and cool, the country being mostly all prairie land helping also. Lath were used for stakes set every hundred feet and hubs on an average of 1,800 ft., a scout flagman being used to set hubs and the field wagon for the transitman to ride in.



Curve of Manhole Costs.

Not a man in the party traveled faster than a walk, with the exception of the level rodman, who finished a mile and a quarter behind the transit party. The boys in the party were very congenial, never heard kicking, and therein lies the secret of their success.

Yours truly,

D. D. MacCrimmon.

Saskatoon, Sask., May 18.

The Cost of the Cold Springs Dam.

Sir: An article appearing in The Engineering Record of May 16 by Mr. A. P. Davis, chief engineer of the U. S. Reclamation Service, gives a review of comparative costs of earthwork on several earth dams, some built by contract and two directly by the Government under its engineers. Mr. Davis' statement that the lowest bid received for the construction of the Cold Springs dam in Oregon was 31 cents per yard for earth and 45 cents for gravel is incorrect. The bid by Clement, Strange & Salisbury, of Salt Lake City, given Sept. 17, 1906, at Portland, Ore., was 29 cents for earth and 35 cents for gravel, an average on the proportions mentioned by Mr. Davis of 33.5 cents. The bid was rejected on the ground that it was too high and that sufficient money could be saved to justify the Government doing the work itself. The writer inspected the site and prepared the bid for the firm mentioned, and has examined Mr. Davis' figures with some interest.

The following is based on Mr. Davis' statement of proportions of earth and gravel in the dam, viz.: Three-fourths gravel and one-fourth earth, requiring on his estimate 590,000 cu. yd. of gravel and by that proportion 196,667 yd. of earth. Using the charges per yard, shown in Table 2 of his article, viz., for engineering, superintendence and general expense, 5.7 cents on gravel and 3.7 cents on earth, on the above quantities we get a total charge of $40,906.68. Will Mr. Davis claim, as is the inference in his article, that the engineering and incidental superintendence charges would approximate that amount if the work had been done by contract? What force of engineers and inspectors would the Reclamation Service have kept upon a job of such dimensions to supervise it, give lines and grades and the like?

The contract period for the completion of the dam, against which contractors were required to bid, to furnish a $75,000 bond and suffer a forfeit of $100 per day for all overtime, was set at Jan. 15, 1908; permitting a possible construction period of about thirteen months from the time an outfit could be put on the ground. For such working time, would not $600 per month be ample for a resident engineer and such assistants as might be necessary to lay out work and for general inspection or supervision, a total of $7,800 for the thirteen months, or one cent per yard as against $40,906.68 charged to that account per Mr. Davis' data? I submit that Mr. Davis' estimate is entitled to a credit of one cent per yard for engineering, etc., from the average cost of 33 cents to permit its comparison with a contract bid, giving a net cost of 32 cents. This, however, seems to leave a saving of 1.5 cents per yard if we neglect the time element and the $3,000 monthly forfeiture penalty demanded of the contractor.

On the basis of six months' overtime expiring June 15, and I believe the work is not yet completed, the above estimated cost of 32 cents per yard under Government construction should carry an additional charge of 2.28 cents, making a total of 34.28 cents.

The time element must be considered if a fair comparison is to be instituted, for it would cost a contractor more to build the dam by Jan. 15 than if allowed till June or July.

From this standpoint, where is the 38 per cent. of saving claimed by Mr. Davis for direct Government construction to be found?

Respectfully,

V. P. Strange.

Salt Lake City, June 8.

Freezing Weather was pleaded as an excuse for not doing a workmanlike job on some houses in Iowa, but the Supreme Court of that state has recently ruled, 115 N. W. Rep. 1,106, that "if it were to be conceded that the season had something to do with the faulty foundation, the plaintiff undertook to erect the buildings at that particular season and do a first-class job. There was no provision in the contract whereby he was relieved from protecting his work or materials from the effects of freezing weather, and he cannot now claim that he should be released from liability because thereof. The evidence conclusively shows that buildings may be safely erected at any season of the year, if proper steps are taken to protect the material and construction work, and that such is the case is a matter of almost common knowledge." This decision shows the importance of making a distinct provision regarding operations during the winter, in contracts where the work is likely to be affected by very cold weather.